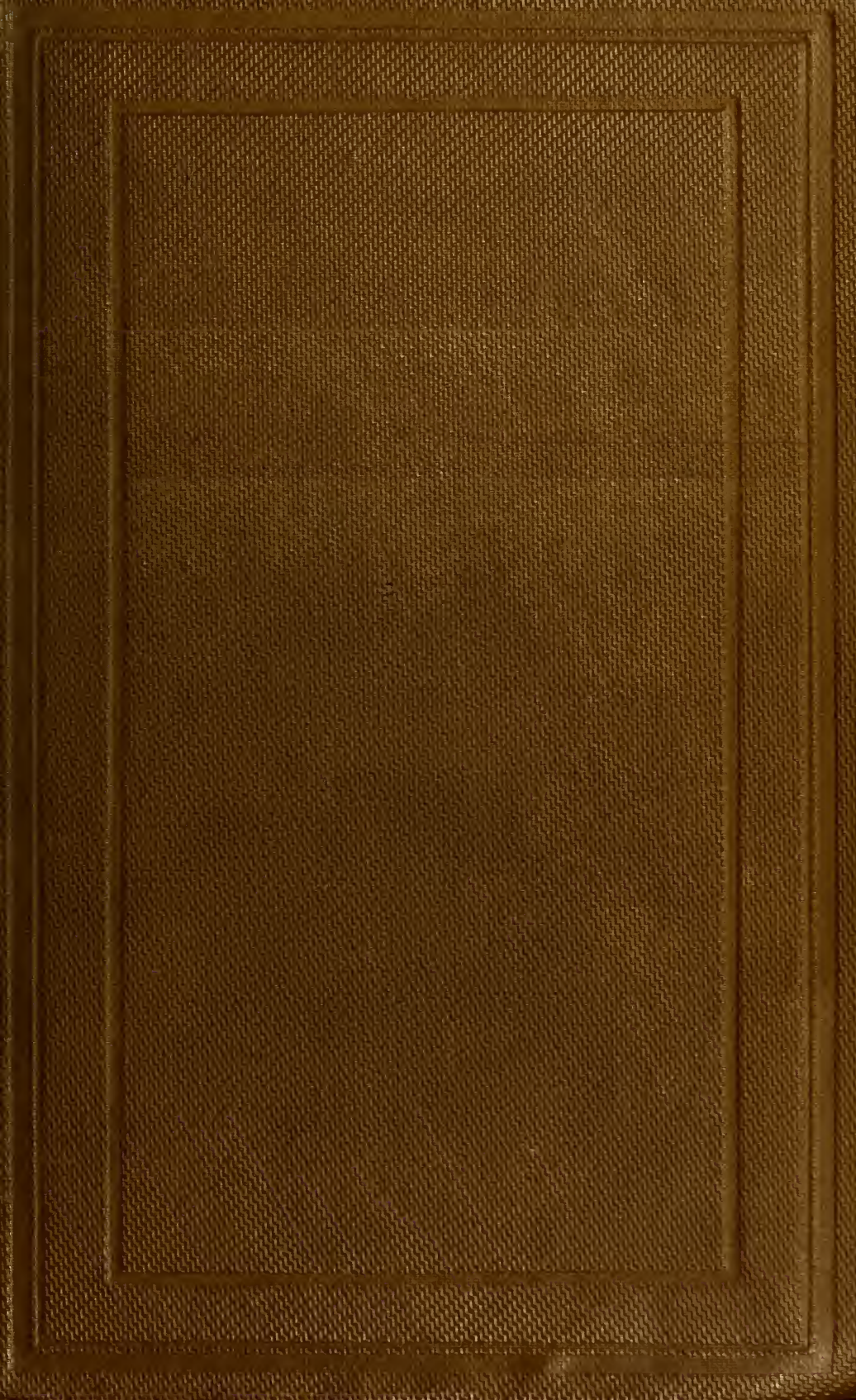




15/-

Natural History Museum Library



000077017

BM
Cb SOP
REI

12 NOV 1926

BRITISH MUSEUM
(NATURAL HISTORY)

CATALOGUE OF CAINOZOIC PLANTS
IN THE DEPARTMENT OF GEOLOGY

VOLUME I

THE BEMBRIDGE FLORA

BY

ELEANOR MARY REID, B.Sc., F.L.S., F.G.S.

AND

MARJORIE ELIZABETH JANE CHANDLER,

YARROW FELLOW OF GIRTON COLLEGE, CAMBRIDGE

WITH A SECTION ON THE CHAROPHYTA

BY

JAMES GROVES, F.L.S.

WITH TWELVE PLATES



LONDON :

PRINTED BY ORDER OF THE TRUSTEES

Sold at THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W. 7,
and by

BERNARD QUARITCH, LTD. ; DULAU & Co., LTD. ;

THE OXFORD UNIVERSITY PRESS ; WHELDON & WESLEY, LTD., LONDON ;
also by OLIVER & BOYD, EDINBURGH.

1926

All rights reserved.

Issued 23rd October, 1926.]

ACCN 183382

PRINTED IN GREAT BRITAIN BY
WILLIAM CLOWES AND SONS, LIMITED
LONDON AND BECCLES

PREFACE

ALTHOUGH the British Cainozoic floras are represented in the National Collection by abundant material, no detailed work has been done on this since the unfinished researches of Mr. J. Starkie Gardner, published by the Palaeontographical Society (1883-86). It was natural that the Catalogue of Fossil Plants in the British Museum should begin with the Palaeozoic and Mesozoic floras, and the delay in starting a Catalogue of the Cainozoic has not been without advantage. Modern methods of study and the improvement of technique enable the work to be carried on to-day with far greater assurance than was possible to the pioneers. At the same time the considerable extension of our knowledge of the living flora permits the discussion of distribution, climate, and similar wide questions to be conducted on a more satisfactory basis.

The recent acquisition by the Trustees of an exceptionally large collection of fossils from the Oligocene beds of the Bembridge series in the Isle of Wight suggested the advisability of beginning this Catalogue with a study of that flora. As Authors of the volume now submitted, the Geological Department has been fortunate enough to obtain, in Mrs. Clement Reid and Miss Chandler, two botanists whose knowledge and skill in this field are second to none. The work that they have produced, with the authoritative co-operation of Mr. James Groves for the *Charophyta*, speaks for itself; my part is merely to record the sincere thanks of the Department for the zeal and generosity with which they have accomplished it. My own thanks, no less than that of the Authors, are also due to Mr. W. N. Edwards, Assistant in the Department, for his help in seeing the volume through the Press.

F. A. BATHER.

DEPARTMENT OF GEOLOGY,
BRITISH MUSEUM (NATURAL HISTORY),
October, 1926.

AUTHORS' PREFACE

WE wish to acknowledge the loan of specimens by the Sedgwick Museum, Cambridge, and the Museum of Practical Geology, Jermyn Street; the gift of fruits and seeds for our collection, on which our comparisons are based, by the Royal Gardens, Kew, the Royal Botanic Gardens, Edinburgh, the Garden of La Mortola, and the Botanic Garden, Brooklyn.

We also offer our most grateful thanks to all those who in one way or another have helped us: The Department of Scientific and Industrial Research for a grant during the earlier part of the work; Dr. Florin, Stockholm, for his most valuable study of *Araucarites*; Dr. Knud Jessen, Copenhagen, for his loan of some of Dr. Hartz' specimens of *Aldrovanda vesiculosa*, and of *Hydrocharis morsus-ranae*; Prof. W. S. Dokturowsky for his timely intimation that he had determined the genus *Aldrovanda* from Pleistocene material sent to us from Galitsch; Mr. G. W. Colenutt for the trouble he took in gathering together information both of A'Court Smith and his work, and of the exact locality from which the fossils were derived; the Keeper of the Geological Department of the British Museum for entrusting to us the study of all the Bembridge fossils in his charge, and Mr. W. N. Edwards, the palaeobotanist of the Department, for his friendly help; but most of all our thanks are due to the Director and officers of the Royal Gardens, Kew, for assisting us in every possible way, giving every facility for work in the Herbarium, helping with living material from the Gardens, material for comparison and photography from the Herbarium, and for constant assistance as the work proceeded.

E. M. REID.

M. E. J. CHANDLER.

CONTENTS

	PAGE
PREFACE	iii
AUTHORS' PREFACE	iv
INTRODUCTION	I
I. History of the A'Court Smith Collection	I
II. The Bembridge Beds	2
III. Previous Records of Bembridge Plants	5
IV. The Fossil Material: its Nature and Mode of Preservation	5
V. Analysis of the Flora in Relation to its Physical Character and Habitat	10
VI. Comparison with certain Selected Fossil Floras	13
VII. The Relation of the Existing Flora of S.W. China and Upper Burma to European Tertiary Floras	22
VIII. The Relation of the Bembridge Flora to other Fossil Floras	25
IX. Climate	28
X. Remarks on a few Special Genera and Species	29
XI. List of Bembridge Species	30
TABLE SHOWING DISTRIBUTION OF LIVING ALLIES OF BEMBRIDGE SPECIES	opposite p. 32
SYSTEMATIC DESCRIPTION	33
PTERIDOPHYTA	33
Polypodiaceae	33
<i>Acrostichum Lanzaeanum</i> (Vis.) (Fig. 1)	33
Schizaeaceae	37
<i>Lygodium</i> sp.	37
Filices Incertae Sedis	37
Salviniaceae	40
<i>Azolla prisca</i> n. sp. (Figs. 2 and 3)	40
Equisetaceae	44
<i>Equisetum lombardianum</i> Sapf.	44
GYMNOSPERMAE	47
Araucarineae	47
<i>Araucarites</i>	47
<i>A. gurnardi</i> n. sp.	48
<i>Doliosirobus</i> sp.	52
<i>Semen Incertae Sedis</i>	53

SYSTEMATIC DESCRIPTION—*continued.*

PAGE

GYMNOSPERMAE—*continued.*

Abietineae	53
<i>Pinus Dixoni</i> (Bowerbank)	53
<i>P. vectensis</i> (Gardner)	54
<i>P. sp. 1</i>	54
<i>P. sp. 2</i>	55
<i>Pityospermum ambiguum</i> n. sp.	55
Taxodineae	56
<i>Sequoia Couttsiae</i> Heer	56
Cupressineae	57
<i>Cupressus</i> sp.	57
? <i>Libocedrus</i> sp.	58

ANGIOSPERMAE	60
Monocotyledones	60
Typhaceae	60
<i>Typha latissima</i> Braun.	60
Sparganiaceae	63
<i>Sparganium multiloculare</i> n. sp.	63
Potamogetonaceae (Fig. 4)	66
<i>Potamogeton pygmaeus</i> (Chandler)	66
<i>P. sp.</i>	67
<i>P. sp. 2</i>	68
<i>Limnocarpus</i>	68
<i>L. headonensis</i> (Gardner)	70
<i>L. spinosus</i> n. sp.	71
Najadaceae	72
<i>Najas oligocenica</i> n. sp.	72
Hydrocharitaceae	73
<i>Ottelia britannica</i> n. sp.	73
<i>Stratiotes neglectus</i> Chandler	74
Gramineae	75
Cyperaceae	77
<i>Carex gurnardi</i> n. sp.	77
<i>C. sp.</i>	77
<i>Cladiocarya foveolata</i> n. gen. et sp.	77
Palmae	79
<i>Sabal major</i> (Unger)	79
<i>Palmophyllum</i> sp.	80
<i>Palaeothrinax Mantelli</i> n. gen. et sp.	80
Araceae	83
<i>Epipremnum ornatum</i> n. sp.	83
Zingiberaceae	84
<i>Spirematospermum Wetzleri</i> (Heer)	84
? <i>Costus</i> sp.	85
<i>Monocotylophyllum</i> sp.	87

SYSTEMATIC DESCRIPTION—*continued*.ANGIOSPERMAE—*continued*.

Dicotyledones	87
Juglandaceae	87
<i>Engelhardtia macroptera</i> (Brongn.) (Fig. 5)	87
<i>E. sp.</i>	93
<i>Hooleyia</i> n. gen.	93
<i>H. Hermis</i> (Unger)	93
Betulaceae	96
<i>Carpinus sp.</i>	96
Fagaceae	96
<i>Fagus sp.</i>	96
<i>Quercus sp.</i>	97
Urticaceae	97
<i>Ficus sp.</i> (Fig. 6)	97
Nymphaeaceae	99
<i>Brasenia ovula</i> (Brongn.)	99
Ranunculaceae	101
<i>Clematis vectensis</i> n. sp.	101
<i>Ranunculus heterostylus</i> n. sp.	103
Lauraceae	105
<i>Cinnamomum lanceolatum</i> (Unger) (Fig. 7)	105
<i>C. Scheuchzeri</i> Heer (Fig. 8)	107
<i>Neolitsea sp.</i> (Fig. 9)	109
Cruciferae?	110
Papaveraceae	111
<i>Papaver pictum</i> n. sp.	111
Droseraceae	111
<i>Aldrovanda</i>	111
<i>A. intermedia</i> n. sp.	113
<i>A. ovata</i> (Chandler)	113
Rutaceae	114
<i>Zanthoxylon (?) costatum</i> n. sp.	114
Rhamnaceae	115
<i>Zizyphus paradisiacus</i> (Unger) var. <i>paradoxus</i> n. (Fig. 10)	115
<i>Rhamnospermum bilobatum</i> Chandler	117
Apocynaceae	118
<i>Apocynospermum</i> n. gen.	118
<i>A. striatum</i> n. sp.	118
<i>A. rostratum</i> n. sp.	119
<i>A. elegans</i> n. sp.	120
<i>A. dubium</i> n. sp.	121
Asclepiadaceae	122
<i>Phyllanthera vectensis</i> n. sp.	122
<i>Tylophora antiqua</i> n. sp.	123
Note on Fossil Seeds of Apocynaceae and Asclepiadaceae	124

SYSTEMATIC DESCRIPTION—*continued.*

PAGE

ANGIOSPERMAE—*continued.*Dicotyledones—*continued.*

Labiatae	126
<i>Melissa parva</i> n. sp.	126
<i>Ajuginucula</i> n. gen.	127
<i>A. Smithii</i> n. sp.	127
Bignoniaceae	128
<i>Catalpa rugosa</i> n. sp.	128
<i>Radermachera pulchra</i> n. sp.	129
<i>Incarvillea pristina</i> n. sp.	130
Acanthaceae	131
<i>Acanthus rugatus</i> n. sp.	131
Caprifoliaceae	132
<i>Abelia</i>	132
<i>A. quadrialata</i> n. sp. (Fig. 11)	133
<i>A. quinquealata</i> n. sp. (Fig. 12)	135
<i>A. trialata</i> n. sp. (Fig. 13)	136
<i>A. sp.</i> (Fig. 14)	138
<i>Dipelta europaea</i> n. sp.	139
Compositae ?	141
Family ?	141
<i>Flabelllicula anglica</i> n. gen. et sp.	141
<i>Samaravectis ovalis</i> n. gen. et sp.	142
<i>Carpolithus actinidiformis</i>	143
<i>C. spp</i>	143
<i>Dicotylophyllum pinnatifidum</i> n. sp.	151
<i>D. spp.</i>	154
<i>Phyllites</i> sp. (Fig. 15)	161
Roots, Stems and Rhizomes	163
Scars	164
Cuticles	164
Flower ?	165
CHAROPHYTA. By J. GROVES	165
Vegetative Remains	167
Fruits	167
<i>Chara medicaginula</i> (Lamarck) (Fig. 16)	167
<i>C. helicteres</i> Brongniart	169
<i>C. tuberculata</i> Lyell (Fig. 17)	170
<i>C. vasiformis</i> Reid & Groves	171
<i>C. vespiiformis</i> n. sp. (Fig. 18)	171
<i>C. subglobosa</i> n. sp.	172
<i>C. vectensis</i> n. sp. (Fig. 19)	172
<i>C. perpusilla</i> n. sp. (Fig. 20)	173
LIST OF WORKS QUOTED	175
EXPLANATION OF PLATES	183
INDEX	199

INTRODUCTION

I. HISTORY OF THE A'COURT SMITH COLLECTION

THE material which forms the subject of this catalogue was collected after the middle of the nineteenth century by James Edwin Ely A'Court Smith (1814-1900). In his youth A'Court Smith served as a midshipman on the *Reliance*, belonging to the Honourable East India Company. Later he joined the Merchant Service, and, after serving as chief officer, retired in 1859 with a master mariner's certificate. He settled at Gurnard, Isle of Wight, and spent his leisure in the study of the geology of the neighbourhood. He discovered the richness of the fossiliferous outcrop of Bembridge beds, near Gurnard, and gathered together the magnificent collections of fossil insects and plants which bear his name.

The deposit was found to be most productive on the foreshore at Gurnard Ledge and at Saltmead Ledge, in Thorness Bay. The Insect Limestone, which contained the best fossils, thickened out and formed a series of weed-covered rocks, extending to and beyond low-water mark. Over a period of many years this keen and tireless student laboriously carried home blocks of stone, which he then carefully broke up and studied at leisure.

The fossiliferous outcrop was of limited extent, and A'Court Smith informed Mr. G. W. Colenutt, F.G.S., to whose kindness we owe most of this information, that he believed he had virtually worked it out.

In 1877 the British Museum purchased "280 specimens of Plants, Mollusca, Crustacea and Insects," from A'Court Smith. Nearly a hundred were registered as plants, but some of these have since been transferred to the Insect collection, as their plant remains were unimportant. In the following year 125 plants were purchased; some of these were inferior or worthless specimens which have not been catalogued. A further purchase in 1883 of "a series of 311 selected specimens of Plant, Insect, Crustacean and Fish Remains" did not include many plants.

Subsequently, the main collection, including several thousand plants and insects, was offered to the British Museum, but was refused because the price was considered excessive. A'Court Smith evidently disposed of a few specimens elsewhere, and some of these found their way to the British Museum. A few of them were in the insect collection of the Rev. P. B. Brodie, acquired in 1898. Others, transferred from the Botanical Department in

1898, may possibly be part of the 1877 or 1878 purchases, which had been sent to William Carruthers, then Keeper of Botany, for examination.

Individual blocks with plant remains are to be found in other museums, including the Sedgwick Museum, Cambridge (specimens figured by Gardner, 1886, pl. xxii, figs. 1, 2, as *Doliostrobus Sternbergii* Goeppert), and the Museum of Practical Geology, Jermyn Street.

A'Court Smith died in 1900, and soon afterwards a well-known geologist, the late Mr. R. W. Hooley, discovered the collection among the lots put up for auction at a sale in Southampton, where he purchased it for a few shillings. In 1923, after Mr. Hooley's death, the whole of his collection, including the A'Court Smith collection, was acquired by the Trustees of the British Museum from his widow.

In 1922 we were asked to undertake the study of the plants, and early in 1923 we received about 650 selected specimens from Mr. Hooley. Later, he sent the whole collection, amounting to between 3000 and 4000 rock fragments. Many of these showed merely the very poor impressions of shreds of vegetation, and were valueless. We met Mr. Hooley upon but one occasion, when he related to us the history of the collection so far as he knew it. The above outline is based on that interview supplemented by information furnished by G. W. Colenutt, Esq., F.G.S., who obtained it from A'Court Smith's twin sons, Messrs. Edwin A'Court Smith and James Henry A'Court Smith.

II. THE BEMBRIDGE BEDS

The beds which yielded the rich flora to be described occur on the north-west coast of the Isle of Wight, in Gurnard Bay and Thorness Bay, about two miles to the south-west of Cowes. With few exceptions (*Palaeothrinax* 38358, *Araucarites* V.15207-8), all the plants were obtained from these localities.

The exposure shows a variable series of clays and marls rich in selenite. These can be seen in the cliff when the section is not obscured by vegetation and landslides, and on the foreshore when the tide is low. At full tide most of the exposure is inaccessible, and, owing to their soft and slippery character, the beds cannot be examined in the cliff-face after a spell of wet weather. The clays and marls, by oxidation and weathering, give rise to red clay-ironstone nodules; and various stages in the consolidation of these may be observed.

Below, the Bembridge marls rest on the freshwater Bembridge Limestone, which forms a conspicuous feature along the cliff and foreshore in Gurnard Bay. Above, the passage into the Hamstead series is very gradual, and Starkie Gardner states (1888, p. 418)

that the two series "are in reality part of an absolutely continuous formation deposited under approximately identical conditions."

In the same paper Gardner says that the plants were collected from more than one horizon in the Bembridge marls—*Sabal major* is said to have been found near the top of the series, the leaves of *Dicotylophyllum pinnatifidum* in great profusion about half-way down in the succession, *Acrostichum* and *Araucarites* (*Doliosirobus* of Gardner) a short distance above the Insect Limestone; while one leaf of *Palaeothrinax* (V.1848) was discovered a little way down in a shelly band of *Cyrena pulchra*; but it is from the Insect Limestone that the majority of the plants were obtained. The diversity of horizons is shown by the different matrices in which the plants occur.

The Insect Limestone forms a well-marked horizon of flat, discontinuous lenticles from 1 inch to 1 foot thick, a few feet above the Bembridge Limestone proper. It can be seen in the cliff section in Gurnard Bay, but westwards is gradually brought down to shore-level by the dip, so that in Thorness Bay its outcrop is on the foreshore (see p. 1). It is a fine calcareous mudstone, when fresh, blue-grey in colour, weathering to buff or brown. Thanks to the extraordinary fineness of the matrix, minute details of structure and nervation are marvellously preserved, even in impressions. The fossils are often made conspicuous by iron-staining, which may colour the organism itself, or form a corona in the surrounding matrix. In parts the stone is coarser, and then the plant remains are less well preserved. The great bulk of the Insect Limestone is barren, as both plants and insects occur in pockets. On a visit to the coast, in the summer of 1925, we found no fossiliferous pockets *in situ*, although we traced the barren limestone along the whole exposure; but that such fossiliferous pockets may occur, even now, was proved by the plant-bearing nodules which we picked up on the beach near Gurnard Ledge. These stones contained fossils characteristic of the A'Court Smith collection—fruits of *Ranunculus* and *Azolla*, also *Typha* fruits and leaves.

As rich pockets are scarce, it is singularly fortunate that a man with such keen perception as A'Court Smith should have been able to devote at least twenty years to patient collection from this exposure. Similar pockets may appear at any time as erosion proceeds; it is therefore desirable that the cliff section should be kept under observation, preferably by a local observer.

The finest specimens in the A'Court Smith collection are preserved in the Insect Limestone, e.g. *Engelhardtia*, *Hooleya*, *Azolla*, *Ranunculus*, *Abelia*, *Clematis*; but there are many plants, such as *Acrostichum*, *Araucarites*, *Equisetum* and *Dicotylophyllum pinnatifidum* preserved in dark, or light, clay-ironstone nodules. Usually each species is confined to one kind of matrix, but there are a few exceptions. *Dicotylophyllum pinnatifidum* is also

found in soft white marl; *Equisetum* occurs abundantly in the red nodules, and rarely in the soft white marls; while *Brasenia* and *Araucarites* occur in any matrix (Gardner, 1886, p. 96).

Except in the basal beds, which are marine, the fauna of the Bembridge marls consists of mammals, turtles, crocodiles, fish, and a few genera of freshwater and estuarine mollusca, in addition to very numerous insects. This fauna and the general character of the beds are stated in the Survey Memoir to point to an estuarine origin. The presence of *Acrostichum* [*Chrysodium* Fée], usually a brackish-water genus, lends some support to this view. At the same time certain seams are described as containing freshwater forms only, among which is the Insect Limestone.

We may therefore picture the beds as deposited in a large delta with extensive mud-flats, in an area of depression subject from time to time to changes of level which controlled the invasion or exclusion of the sea (cf. Gardner, 1879, p. 98).

To account for the sporadic occurrence of the fossils, especially in the Insect Limestone, A'Court Smith suggested that they were left by eddies in pockets.

All authors are agreed that the Bembridge marls represent a part of the Oligocene formation, but their occurrence in an estuarine series renders exact correlation with the deposits of other regions a matter of some difficulty. Opinions as to correlation naturally vary, therefore, but only within fairly narrow limits; thus some authors place the beds in the Lower Oligocene, while others regard them as of Middle Oligocene age.

There appears to be fairly general agreement that the conformable overlying Hamstead beds are equivalent, entirely or in part, to the Fontainebleau beds of the Paris Basin and the Stampian of Etampes, while geologists are also agreed that part at least of the Headon series should be correlated with the Ludian of the Paris Basin. If this be so, then the Bembridge marls must lie somewhere between the Ludian and the lower part of the Stampian. They may either correspond to the base of the Stampian or the upper part of the Sannoisian.

If the whole Headon series be regarded as Eocene, then the Bembridge marls would probably belong to the Sannoisian, or Lower Oligocene, as de Lapparent suggests (1900, p. 1550).

If, on the other hand, the whole Headon series be placed in the Oligocene (Judd 1880, White 1915), the Bembridge marls would have to be regarded as Middle Oligocene.

If, however, the base-line of the Oligocene be drawn between the Lower and Middle Headon series, so that the Middle Headon marine beds represent the deposits of the transgressing Oligocene sea, as Boussac (1907), Stamp (1921), and others hold, then the Bembridge marls must be classified as either the top of the Lower, or base of the Middle, Oligocene.

III. PREVIOUS RECORDS OF BEMBRIDGE PLANTS

Although geologists have known for many years that a rich flora occurs in the Bembridge marls of Gurnard Bay, very little work on the subject has been published.

In his monograph on Eocene Floras, Gardner (1883-6) figures and describes a cone of *Pinus Dixoni* Bowerb. (pl. xiii, fig. 4) from these beds, and a twig (pl. xiii, fig. 7) which he refers to *Araucarites Goepperti* (?) Sternbg. On pls. xxii and xxiii twigs are figured under the name *Doliosirobus Sternbergii* Goepp. (= *Araucarites*). On pl. vi, fig. 9, pl. xxii, fig. 10, and pl. xxvii, fig. 4, are small twigs referred by Gardner to *Athrotaxis* (= *Sequoia*) *Couttsiae* (probably not a *Sequoia*, p. 56).

Two papers by Gardner in the Reports of the British Association add a few plants to the flora. In the earlier of these (1886a, pl. iii, figs. 1-6), figures are given of *Gleichenia*, subsequently transferred by Gardner to *Myrica* (= *Dicotylophyllum pinatifidum* of the present authors), *Chrysodium* (*Acrostichum*) *Lanzaeanum*, and an undetermined fragment of fern. In the later (1888, pl. iii, figs. 1-9, 31-34, pl. v, figs. 1, 2) the following plants are figured: *Carpolithus globulus* (= *Brasenia*), *Pinus vectensis* cone, *Doliosirobus Sternbergii* (= *Araucarites gurnardi* Florin), *Flabellaria Lamanonis* (= *Palaeothrinax Mantelli*), and *Sabal major*; also there is mention in the text of *Engelhardtia* sp., *Carpolithus Websteri* (= *Stratiotes neglectus* Chand.), *Cinnamomum lanceolatum* and *C. polymorphum* (= *C. Scheuchzeri*), *Zizyphus Ungerii* (= *Z. paradisiacus* var. *paradoxus*), *Rhus* (not a *Rhus*), *Viburnum* (not a *Viburnum*), *Ficus*, and *Lygodium* (probably not *Lygodium*). The seven last were identified in collaboration with de Saporta.

The list on p. 183 of the Survey Memoir (Bristow, 1889) merely recapitulates these species. Since 1889 nothing new has been published on the subject.

The leaves previously determined by Gardner and de Saporta have all been re-investigated; the determinations being sometimes accepted, sometimes rejected, as indicated in brackets above.

IV. THE FOSSIL MATERIAL: ITS NATURE AND MODE OF PRESERVATION

The Bembridge plants are represented by remains of both vegetative and reproductive organs.

STEMS AND LEAVES: The vegetative remains are for the most part very fragmentary, but a few leaves are perfect, and others, though now broken, appear once to have been perfect, and are well preserved. Most of the leaves of dicotyledons appear to be

those of land plants, and the individuals of each species are few. In marked contrast as to numbers are the leaves of *Dicotylophyllum pinnatifidum* of a type referred by various authors to *Myrica*, *Banksia*, *Dryandra*, or *Gleichenia*. Starkie Gardner states that it occurs in enormous profusion (1888, p. 419). Besides these we find stems of *Equisetum*, stems and leaves of *Typha* and the leaves of various other monocotyledons, mostly aquatic or semi-aquatic plants—*Potamogeton*, *Epipremnum*, *Costus*, another species of Zingiberaceae, and a large grass. Also there are leaves and twigs of conifers—*Araucarites*, a species of *Libocedrus* (?), and pine-needles ; and the remains of Cryptogams—fragments of fern and of *Azolla*.

FRUITS AND SEEDS : The number of recognisable species represented by fruits and seeds is much greater than the number represented by determinable leaves. Those occurring in the greatest numbers are of two kinds.

(1) Fruits and seeds of land-plants especially adapted for wind-dispersal, such as *Engelhardtia*, *Hooleyia* (an extinct genus of Juglandaceae), *Abelia*, *Clematis*, and various Apocynaceae.

(2) Fruits and seeds of water-plants, such as *Sparganium*, *Brasenia*, *Stratiotes*, *Potamogeton*, *Limnocarpus* (an extinct genus of Potamogetonaceae), and *Ranunculus*, which is probably an aquatic or semi-aquatic species.

In lesser numbers are many species—of *Melissa*, *Papaver*, *Ajuginucula*, etc.—which in many instances are represented by but a single specimen.

All fossil leaves have been compared with those of the living genera to which any fruits and seeds have been referred. Similarly the fossil fruits and seeds have been compared with those of all living genera to which leaves have been referred. The result shows that very few species are represented by both vegetative and reproductive organs. *Araucarites* possibly is ; *Radermachera* may be (see pp. 155, 156, and Pl. X, fig. 16) ; but these are the only land-plants. Of aquatic or semi-aquatic plants, the leaves, fruits and seeds of *Typha* and *Potamogeton* undoubtedly occur, the former in abundance ; and possibly the leaves of *Spirematospermum* are also represented by one or two specimens.

This is what would be expected in an aquatic deposit into which land-plants must have found their way by chance, water plants with more certainty.

The major part of the evidence has been derived from impressions and casts ; whether external impressions of leaves, stems, fruits and seeds, or internal casts of hollow stems (*Equisetum*), of the locules of fruits (*Sparganium*, *Limnocarpus*), of air-spaces (the lacunae in the leaves of *Typha*), or of individual cells (the endosperm cells of Apocynaceous seeds). In a good many species it has been possible to supplement this evidence by the study of the carbonised remains. In most specimens the car-

bonaceous matter has decayed, although there is evidence in fresh fractures of the stone that decay is increased by exposure to the air and neglect. Yet very occasionally among fruits, seeds, spores, and even leaves, the carbonised entity, or part of it, remains. In the case of fruits, seeds and spores, it has then been possible to remove it from the stone, examine it as a free entity, and even dissect it. Notably this has been done in the case of *Azolla*. The organic substance of leaves and stems is, as a rule, much more decayed and fragmentary. Yet even so it has been possible to make a few cuticle preparations. These were obtained by chipping off fragments of the lamina, and then treating them in the usual way with nitric acid and potassium chlorate. Preparations of *Araucarites* which were sent to Dr. Rudolf Florin were further treated by him with hydrofluoric acid. *Azolla* was usually treated with nitric acid and potassium chlorate, but a few preparations were made with eau de Javelle, and some were stained with carbolfuchsin. They were mounted either in glycerine or Canada balsam.

PRESERVATION OF ENDOSPERM: In many specimens of albuminous seeds such as *Clematis*, *Ranunculus*, various Apocynaceae, etc., the endosperm is in part preserved as a cream-coloured granular substance enclosed in the remains of a hyaline membrane. It would appear that mineral matter in solution must have penetrated the cell-walls of the endosperm, replacing the cell contents, and that later the cell-walls decayed, leaving the internal casts of the individual cells as discrete particles lying within the hyaline tegmen.

SHRINKAGE: The association of organic remains with sharply defined impressions has enabled us to obtain valuable information as to the shrinkage which may be incident upon fossilisation. In many cases where fruits have been freed from the matrix, they have lain free within their hollow moulds, so that when these were opened the fruits fell out. Similarly the carbonised leaves of *Araucarites*, in the rare instances when these have been found, have lain free within their hollow moulds. In the case of one leaf of *Araucarites* the mould measured 5 mm. in length, the actual leaf 4 mm.; a shrinkage of 20 per cent. of the original dimensions. More often it is less than this. Similar evidence of shrinkage is shown, where free contraction of the organ has been in any way impeded, by the fracture of the organic remains perpendicularly to the direction of strain.

The observations are of especial interest in view of our common experience that fossil fruits and seeds often differ from those of living species only in their somewhat smaller dimensions. Shrinkage has suggested itself as the cause of this smaller size, but we have never before met with direct evidence on the subject.

METHODS OF STUDY: From what has been said above it will be seen that two methods of study are available for the different

elements of the Bembridge flora, according to their state of preservation, and that very occasionally the two can be applied to the same species, or even the same specimen. We refer to the study of impressions or casts revealed by fracture of the stone, and to the study of the free entities released from the stone.

In the case of the Bembridge specimens, almost all the carbonised fossils released from the stone have been obtained by first fracturing the stone so as to break open the hollow mould in which the organic entity lies free, the latter being allowed to fall out; but a few have been obtained by the method which has hitherto formed the basis of our palaeobotanical work, namely by disintegrating the matrix and releasing the contained fossils. We were able to follow this last-named method with a small quantity of soft Bembridge marl which disintegrated when soaked in water. The difficulty of using the method with the Bembridge marl lies, not in any difficulty in disintegrating the stone, but in the fact that the contained fossils are so rotten, that when released and the strain relaxed, they fall to pieces and become unrecognisable. This happened with most of the fossils in the case we refer to. The only recognisable fossils obtained were a large number of *Chara* fruits, a few damaged or fragmentary fruits or seeds of *Potamogeton*, *Limnocarpus* and *Brasenia*, and the beautiful little seed of *Papaver pictum* (Pl. VII, figs. 18, 19). Had it been possible to treat more material in the same manner it is probable that other small seeds might have been obtained. They seem more often to escape destruction than large seeds, and better to withstand decay. It is also possible that, as in the case of *Papaver*, more evidence of herbaceous land-plants might have been found.

It will readily be understood that the method of study to be followed in any particular instance must depend not only on the character of the matrix but upon the state of preservation of the contained fossils, and the possibility of releasing them without destroying them. In the case of impressions, fracture can, of course, alone be used.

There are different advantages in the one and the other method. By disintegrating the matrix the whole contents of the rock are released, and so a greater mass of material becomes available for study than can be obtained by fracture. Also there is less danger of damaging or destroying the specimens so as to render them unrecognisable and useless.

Our own experience of the two methods is that impressions alone, with no carbonised entity accompanying them, give nothing but the outward (or inward, in the case of locules, etc.) form. Unless the form be very characteristic, as in the fruits of *Dipelta*, *Hooleya*, and *Abelia*, and the seeds of *Acanthus* and Bignoniaceae, etc., or unless there be very marked external characters such as spines, ridges, or a prominent raphe, then the evidence may be insufficient for definite determination (see various *Carpolithus* spp.

preserved as casts or impressions only). On the other hand, in a fine matrix the impressions of delicate external organs, such as the spines of *Potamogeton*, the stalk and style of *Typha*, the styles, sepals and involucre of *Engelhardtia*, the styles of *Ranunculus* and *Clematis* may be preserved with a perfection we have never seen when fossils have been released from seed-beds.

Yet although we do not find this perfection of preservation when fossils are released from the matrix, there is compensation in the fact that they can usually be dissected so as to afford internal as well as external evidence. When, as occasionally happens in the Bembridge material, such delicate impressions are associated with carbonised remains, then we get a completeness of information surpassing any which we have previously known. This perfection of preservation is found in the case of *Sparganium*, *Typha*, *Potamogeton*, *Limnocarpus*, *Ranunculus*, and especially *Azolla*.

Allusion has been made to the fragmentary condition of some of the Bembridge fossils, but it is necessary to discriminate between the causes of this condition. Some, notably the remains of *Equisetum*, *Araucarites*, and *Typha*, are obviously imperfect because they were torn and damaged before fossilisation; but a great many are imperfect because the stone has been broken either by buffeting on the shore, or in the course of collecting and fracturing for investigation. Or, again, the fossils may appear to be imperfect because parts lie in different planes, and it is impossible to expose them all.

It will be seen from the above description of the state of preservation of the Bembridge fossils that they hold an intermediate position between impressions pure and simple to be studied in the matrix, and releasable fossils to be studied as free entities; that is, between the type of fossil usually found in leaf-beds and the type usually found in seed-beds.

Well-preserved leaves, and organs with delicate appendages do not ordinarily occur in a perfect state in seed-beds. At least, we have met with them but very rarely (awns of *Dulichium* in one or two specimens, and spines of *Rumex maritima*). It is true that pockets of seeds associated with a coarse matrix, and pockets of leaves associated with a fine matrix may occur in the same series, but perfect leaves and delicate appendages are not met with among coarse seed-bearing matrices. Leaves are torn to shreds, and fruits and seeds have lost their wings and pappus (cf. *Acer* from the Cromerian, *Pterocarya* from the Reuverian and Teglian, *Liriodendron* and *Anemone* from the Reuverian, *Clematis* from the Teglian, and all the many Compositae yet recorded by us).

The contrast is very striking, and demands explanation. It is evident that difference of preservation is associated with difference of matrix, and the latter, in its turn, is associated with difference of water transport. When there has been no transport, as in the case of peat, or when the transport has been very gentle so as to carry

only the finest mud, then leaves and fruits with their delicate appendages may be preserved. When the transport has been more violent, so as to carry coarser clays and sands, they are lost. It is the rough usage of water transport which causes damage.

Yet this cannot be the whole explanation because the fine mud in which the perfect fossils are embedded has suffered greater trituration than the coarser material among which the damaged fossils occur. The delicate, yet perfect, fossils can only have travelled a comparatively short distance with the fine mud. They must have escaped the trituration to which the mud has been subjected in the rough and tumble of moving water. They must therefore have either fallen, or been blown, into the water near the place of fossilisation; or they may have been carried a comparatively short distance by tranquil-moving water. It is noticeable in this connection that the wind-buoyant forms among the Bembridge fossils are most frequently those which are preserved with the greatest perfection.

We may use these differential characters of wind-buoyancy and water-buoyancy, aquatic and non-aquatic habit—*i.e.* free access, or non-free access to water—to discriminate among the elements of the Bembridge flora, and so to obtain fresh light upon the known discrepancies to be found in the results of leaf and seed studies.

V. ANALYSIS OF THE FLORA IN RELATION TO ITS PHYSICAL CHARACTER AND HABITAT

The fossils may be classified under four headings:

1. Those which by their form are shown to be wind-buoyant, and by their perfect state appear to have travelled but a short distance, whether in the air or in tranquil water. These would not be likely to occur in seed-beds.

2. Those which belong to hydrophytic plants and so had ready access to water. This access to the transporting element would give them an almost even chance of appearing either in seed or leaf-beds. Whether they do so or not will depend mainly on the physical character of the organs. Are they, on the one hand, too fragile to withstand the rough and tumble? Are they, on the other, too heavy to reach tranquil water, and be carried by a gentle current?

3. Fruits and seeds with no especial means of transport which would be likely to carry them to the water. These could reach it only by chance: by being swept in during heavy rains and floods; by being carried on the feet or hides of drinking and wallowing animals; or on the feet or feathers of birds.

4. Those of which we know too little to suggest under what category they should be placed—fragments of ferns and badly preserved leaves. These have been omitted from Table I.

TABLE I

ELEMENTS OF THE BEMBRIDGE FLORA CLASSIFIED ACCORDING TO THEIR WIND-BUOYANT CHARACTER AND ACCESSIBILITY TO WATER.

I	II	III
Well-preserved organs : a. specially adapted for wind carriage. b. which could be wind-borne.	Aquatic or semi-aquatic species, any parts of which could probably reach water.	Organs with no special means of transport, neither wind-buoyant nor aquatic.
a. <i>Pinus</i> seeds (few) a. <i>Engelhardtia macroptera</i> (abundant) a. <i>Hooleyia Hermis</i> fruit (abundant) b. <i>Fagus</i> sp. leaf (1) b. <i>Ficus</i> sp. leaf (2) a. <i>Clematis vectensis</i> fruit (abundant) b. <i>Cinnamomum lanceolatum</i> leaf (3) b. <i>Cinnamomum Scheuchzeri</i> leaf (1) b. <i>Neolitsea</i> sp. leaf (1) a. <i>Phyllanthera vectensis</i> seed (several) a. <i>Tylophora antiqua</i> seed (1) a. <i>Apocynaceae</i> spp. seeds (several) a. <i>Catalpa rugosa</i> seed (1) a. <i>Incarvillea pristina</i> seed (1) a. <i>Abelia</i> spp. fruits (many) a. <i>Dipelta europaea</i> fruit (few) b. <i>Zizyphus</i> leaf (1) a. <i>Samaravectis ovalis</i> fruit (few) a. <i>Flabelllicula anglica</i> fruit (1) Many fragments of dicotyledonous leaves, well preserved.	<i>Chara</i> spp. (abundant) <i>AcrostichumLanzaeanum</i> (abundant) <i>Azolla prisca</i> (v. abundant) <i>Equisetum lombardianum</i> (v. abundant) <i>Typha latissima</i> (v. abundant) <i>Sparganium multiloculare</i> (v. abundant) <i>Potamogeton pygmaeus</i> (v. abundant) <i>Limnocarpus</i> 2 spp. (v. abundant) <i>Najas oligocenica</i> fruit (1) <i>Ottelia britannica</i> fruit (few) <i>Stratiotes neglectus</i> seed (abundant) <i>Gramineae</i> various remains (many) <i>Carex gurnardi</i> fruit (3) <i>Cladiocarya foveolata</i> nut (few) <i>Epipremnum ornatum</i> seed (few) <i>Costus</i> sp. leaf (2) <i>Spiromatospermum Weitzleri</i> seed (3) <i>Brasenia ovula</i> seed (v. abundant) <i>Aldrovanda intermedia</i> seed (few) <i>Acanthus rugatus</i> seed (1) <i>Dicotylophyllum pinna-tifidum</i> . Probably aquatic leaf (v. abundant)	<i>Araucarites gurnardi</i> twig (v. abundant) <i>Libocedrus</i> sp. twig (1) <i>Cupressus</i> sp. cone (1) <i>Sabal major</i> leaf (few) <i>Palaeothrinax Mantelli</i> (2) <i>Carpinus</i> sp. nut (1) <i>Quercus</i> sp. nut (1) <i>Zanthoxylon costatum</i> seed (1) <i>Papaver pictum</i> seed (1) <i>Rhamnospermum bilobatum</i> seed (many) <i>Melissa parva</i> nut (1) <i>AjuginuculaSmithii</i> nut (1)

Numbers after species indicate the number of specimens.

The above table is based on the evident physical characters of the fossilised remains, and on the probable habitat of the parent

plant, as indicated by botanical relationship, mode of occurrence, or structure. It may now be examined from the points of view of seed and leaf study respectively.

Except *Clematis*, which was found at Tegelen, and *Fagus*, which was found at Reuver (fruits and seed), and perhaps at Bovey Tracey (C. & E. M. Reid, 1910a, pl. xvi, figs. 67, 68), also *Cinnamomum* (cupules) and *Pinus* at Reuver, no genera named in Column I. have been found by us in seed deposits. We have, however, found Compositae (without pappus) which are physically comparable with the seeds of Apocynaceae.

On the other hand, *Pinus*, *Engelhardtia*, *Hooleya* (= *Hiraea Hermis* Ung.), *Fagus*, *Ficus*, *Clematis*, *Cinnamomum* (both species), *Neolitsea*, Asclepiadaceae, Apocynaceae (= *Cypselites*, pars), *Catalpa* and other Bignoniaceae, and *Zizyphus* have all been recorded from leaf deposits. *Abelia* has not been recorded, but may well be compared in physical characters with *Heterocalyx*. The three remaining genera, *Dipelta*, *Samaravectis*, and *Flabellifolia*, are first records.

Column II. contains numerous genera which have been found in both leaf and seed deposits.

Except *Acanthus* (first record), *Azolla*, *Dicotylophyllum pinnatifidum* (probably a water-plant, see p. 153), we ourselves have found all in seed deposits.

At the same time, *Chara*, *Acrostichum*, *Equisetum*, *Typha*, *Sparganium*, *Potamogeton*, *Najas*, *Ottelia* (cf. also *Vallisneria*), *Stratiotes* (seeds), Gramineae (*Arundo*, Bamboo), *Carex*, Zingiberaceae, *Brasenia* (and other Nymphaeaceae), *Ranunculus*, and especially genera comparable with *Dicotylophyllum pinnatifidum* (*Banksia*, *Myrica*, and *Gleichenia*), all have been recorded from leaf deposits.

Thus water-plants, as would be anticipated, form a link between the two kinds of deposits and the two kinds of study.

Either the actual genera mentioned in Column III. or others comparable have been found in seed beds. Thus, the remains of conifers and *Zanthoxylon* were washed out from the Hordle beds; and Labiates have constantly been recorded.

It will be noticed that in this column the fruits and seeds of (probably) herbaceous land-plants occur—*Melissa*, *Ajuginucula*, and *Papaver*. Hitherto the knowledge of herbaceous land-plants has been derived chiefly from the investigation of seed-beds. The reason for this is not far to seek. The seeds or fruits of almost all plants detach themselves from the parent when they are ripe; but the leaves of herbaceous plants do not. They wither and die whilst still in organic connection with the parent. Consequently, while their fruits and seeds might by chance be carried into the water, it is most unlikely that the leaves would reach it. Thus Column III. affords a link with the study of seeds as Column I. does with the study of leaves.

It follows that discrepancies between the results of the two studies, at least as regards genera, are chiefly incident upon the sifting by wind and water of material differing in physical characters, and by the chances of casual transit dependent on differences of habit and habitat. Such being the case, it is not strange that the two kinds of deposit should tend to preserve a botanical facies of their own; for always the different parts of the same, or similar, plants in any region will tend to react in the same way to the forces of nature and the habits of wild animals.

VI. COMPARISON WITH CERTAIN SELECTED FOSSIL FLORAS

In this part of the investigation we propose to confine ourselves to the results of our own work, for the following reasons :

- (1) It is desirable to discover the trend of our own work.
- (2) The personal equation being the same throughout, the results are more comparable than when other personal equations are involved.
- (3) Because much of the classic work on European Tertiary plants was carried out when the existing floras of South-West China and Upper Burma were almost unknown—exactly those floras with which the European Tertiary floras show the closest alliance.

It was the remarkable association between the living flora of these regions and the flora of the Dutch Pliocene, revealed by work in Kew Herbarium during the years 1909-1912, that first brought home to one of us the measure and significance of the alliance. In later years an attempt was made to separate the species of Far Eastern and American alliance from those of European alliance in certain Pliocene floras with the aim of learning more of their history (Reid, 1920a). The essential hypotheses underlying the investigation were :

(1) That European Pliocene plants of East Asian and American affinity had migrated southward from a common circumpolar source together with many Asiatic and American plants.

(2) That plants of European specific affinity had a different history of migration from those of East Asian-American specific affinity, because, whatever that history were, it did not involve their destruction in Europe.

(3) That since destruction of species and genera was coincident with the presence of E.-W. mountain chains, and survival with N.-S. mountain chains, it was the direction of the mountain chains which determined destruction or survival, because it determined whether there should, or should not, be free passage between the climatic zones.

In so far as this work differed from that which had preceded it along the same lines, it was, perhaps, in

- (1) Its more definite statement that the whole East Asian-

North American element in the West European Pliocene was *one* in derivation from a circumpolar source with much of the living floras of East Asia and North America ; but that in the one case it was destroyed, in the other it survived.

(2) Its definite attempt to discriminate this flora as one whole from the flora of European affinity as another whole.

(3) Its attempt, by making this discrimination numerical, to use it as a means of tracing the history of plant life, and of discovering new facts.

In studying the components of the Bembridge flora we propose to follow the same line of research, using as data for comparison the *genera* found in three other floras living at fairly wide intervals during the Tertiary Period : the Upper Eocene of Hordle (Chandler, 1925), the Mio-Pliocene of Pont-de-Gail (Reid, 1920*b*), and the Middle Pliocene of Tegelen (C. & E. M. Reid, 1907).

The investigation is concerned with genera primarily, but inasmuch as in considering geographical distribution, even on very broad lines, the specific relationship is usually involved, we have also to take account of specific alliance. Therefore we consider in the present instance those genera, only, for which the specific relationship has been determined with great certainty. Again, in order to simplify the discrimination between the European and East Asian-American relationships, the latter being that shown by nearly all non-European genera, we have omitted from this investigation all genera whose nearest allies are now found both in Europe and East Asia or America. These are very few. We draw attention to this because in a later study (pp. 27, 28), on simpler lines, these are included, and a consequent slight difference follows in the result.

The genera are grouped according to present geographical distribution ; those related to East Asian and American species being united as one group, because there is a well-known alliance between the living floras of these regions, and because in these two regions alone has there been, for long ages, free passage from one climatic zone to another. Similarly, African and Indian genera are grouped because, again, for long ages, these regions have been severed from direct communication with those immediately north of them.

Under the term "East Asian" is included the whole of East Asia from Japan and China to the Malay Peninsula, Formosa, and the Philippine Islands, the islands of the Malay Archipelago, New Guinea, Australia, New Zealand and Tasmania. These are described as the regions of the East Asian corridor.

Under the term "American" is included both North and South America. These are described as the regions of the American corridor. The two corridors are ways of access from one terrestrial zone to another.

The genera are listed under various headings to be explained

immediately. The lists will be found on pp. 18-22. Table II. shows the numbers occurring under the different headings in each flora, with the same numbers expressed as percentages. The reason for the statement in percentages is to provide a general basis for comparison of one flora with another, whereby the underlying facts become apparent; for we seek for the broad lines of the changes that were going on. A percentage statement adds no definitiveness to any statement; it merely casts it into a more general form, in which it can be used for comparison.

With the exceptions already stated, the plants from the four deposits are divided into two main groups:

A = all genera now European.

B = all genera not European. In every case the genera classed under B are found to live either in East Asia or America, although not always wholly within these regions.

Each of these main divisions is then subdivided. A is divided into:

A' = those European genera of which the species show European affinity.

A'' = those European genera of which the species show East Asian-American affinity.

B is almost homogeneous as showing East Asian-American affinity in its species. The one exception is *Chlorophora* (Hordle), which shows alliance with an African species.

Although all genera in B are East Asian or American, all are not exclusively so. Some have a wider range into Africa and/or India and the Mascarene Islands; that is to say, to the south of the transcontinental barrier which, at some periods and in some regions, has been formed mainly by mountain chains; at other times, or in other regions, by seas. Such a barrier appears to have maintained its general position since early Eocene times. B is divided thus:

B' = genera exclusively East Asian-American.

B'' = East Asian-American genera with wider range outside.

B''' = East Asian-American genera with wider range, of which the *specific* affinity is African.

Hence, to study the change in the flora from genera of East Asian-American alliance, to genera of European alliance compare B and A.

To study the change in the flora from genera having *specific* alliance with East Asian-American forms, to those having *specific* alliance with European forms, compare C (= A'' + B - B''') with A', because

$$C = \begin{cases} A'' = \text{European genera with East Asian-American specific affinity.} \\ + \\ B = \text{East Asian-American genera with East Asian-American specific affinity.} \\ - \\ B''' = \text{East Asian-American genera with African affinity.} \end{cases}$$

A' = European genera with European specific affinity.

To study the change from a flora with genera having now a wider range into Africa or India, to a flora with genera now confined within the East Asian-American corridors, compare B'' with B'.

Finally, B''' shows the genera having specific affinity outside the East Asian and American corridors. At the same time this is very slight in the deposits we have investigated.

TABLE II

SHOWING BIOGEOGRAPHICAL ALLIANCES OF GENERA IN FOUR TERTIARY FLORAS

		Mid. Pliocene Tegelen.	Mio- Pliocene* Pont-de- Gail.	Mid. Oligocene Bem- bridge.	Upper Eocene Hordle.
	Number of genera compared ..	50	32	28	27
A	European genera	42 (84)	15 (47)	9 (32)	8 (30)
A'	European genera with European specific alliance	41 (82)	7 (22)	3 (11)	2 (8)
A''	European genera with E. Asian- American specific alliance ..	1 (2)	8 (25)	6 (21)	6 (22)
B	Non-European genera (all live in E. Asia or America)	8 (16)	17 (53)	19 (68)	19 (70)
B'	Non-European with exclusive E. Asian-American range	8 (16)	14 (44)	13 (47)	13 (48)
B''	Non-European ranging into Africa and/or India	0 (0)	3 (9)	6 (21)	6 (22)
B'''	Non-European with specific al- liance in Africa and/or India ..	0 (0)	0 (0)	0 (0)	1 (3)
C	Genera with specific E. Asian- American alliance	9 (18)	25 (78)	25 (89)	24 (89)

The figures in brackets give the percentages of the total number of genera in each flora. For lists of genera, see pp. 18-22.

* We learn by letter from Mr. Marty that the latest palaeontological work on the deposit of Pont-de-Gail indicates that it is probably older than at first was thought. He suggests that it is Mio-Pliocene, but informs us that it may even be Miocene, although by some it is still regarded as Pliocene.

The broad lines of the history of the European flora shown by the above investigation are the following :

(1) That a series of gradual changes took place between the Upper Eocene and the end of the Pliocene, by which the flora was transformed from one mainly of East Asian-American affinity, to one of European affinity. It is to be noted that except *Stratiotes* every genus in the Hordle flora lives in East Asia or America. The same is true of the Bembridge flora.

(2) The transformation first began to be marked by changes in genera. The genera ceased gradually to be preponderatingly East Asian-American. They became more and more European ;

but it was not until after the Middle Pliocene that the transformation was complete. In the Tegelen flora still only 84 per cent. (or rather more, cf. p. 27) of the genera were European. It was only in the Cromerian that the whole flora was Europeanised.

(3) Although this introduction of European genera was going on, it did not Europeanise the flora, because the *species* representing the European genera continued to be largely East Asian-American. Consequently the flora preserved its dominantly East Asian-American character well into the Pliocene. In the Mio-Pliocene of Pont-de-Gail a very large percentage of species was still East Asian-American; some belonging to East Asian or American genera, some to European genera. We do not give a full discussion of the change in *species* in the present work, because we are here dealing with genera irrespective of the number of species represented in each. The subject of the change in species during the Pliocene has been previously dealt with (E. M. Reid, 1920a, pp. 145-161).

(4) There was another change going on in the earlier period of our investigation. The table shows very clearly that many of the genera of the Upper Eocene flora, although all are found either in East Asia or America, have now a wider range into Africa, India, or the Mascarene Islands. Further, it shows that this element was dying out, and by the Middle Pliocene had vanished.

(5) However, this element was not marked by alliance with African or Indian *species*. The specific alliance was almost completely with East Asian or American forms. It is only the *genera* allied to the fossils that spread wider; not the *species*.

(6) *Chlorophora* in the Hordle flora is an exception, and it may be an indication of a yet older element, almost extinct in the Upper Eocene; an element allied directly with African or Indian forms. Such an indication would be in conformity with the results of de Saporta's researches (1879, pp. 370, 371). We mention it, but without emphasis, as it is so slight. Still, we cannot ignore it.

The deductions from these facts which suggest themselves are the following, beginning at the opening of our period:

(1) That the African and Indian alliance shown in genera, but not in species—which was small and already dwindling when our investigation opens, and was the first alliance to die out—was one of the oldest met with in those Tertiary floras now under consideration. The oldest of all is probably represented by *Chlorophora*.

(2) That since the specific relationship seen in the genera of African alliance (not *Chlorophora*) is to East Asian or American forms, this element of the Tertiary flora must have entered Europe in association with the East Asian-American element; not directly from Africa or India.

(3) Any direct connection between the East Asian-American and African and Indian floras must already have ceased before the

end of the Eocene ; otherwise the African character would have been equally impressed upon this part of the European Tertiary flora with the East Asian and American.

The changes in the Tertiary flora described above have been brought to light merely by classifying the various elements with regard to the following considerations : (1) The biogeographical relationships of living floras as seen in the alliance of the East Asian and American floras. (2) The botanical relationships between past and present floras. (3) The influence of zonal barriers in separating floras to the north and south of them, and in causing extermination.

Since, when viewed in this manner, the gradual process of change becomes apparent, we believe that the cause of the change is best explained by the theory of a continued southward migration of plants, in the Northern Hemisphere, from some circum-polar source, during the Tertiary Period—certainly from as early a time as the Middle Eocene ; the migration being interrupted during this time by barriers of one kind or another throughout most of Asia and the whole of Europe, but uninterrupted in the Far East and in America. At an earlier period, however—probably during the Early Eocene or the Paleocene—the barriers would appear not to have been operative between Europe and Africa because, as we have seen in the case of *Chlorophora* in the Hordle flora, we have a species witnessing to direct connection with Africa. Almost certainly, since the rest of the flora indicates a breach of connection between the two continents, this is a lingerer from an older flora.

LIST OF GENERA COMPARED FROM FOUR FLORAS

The columns from A to C are the same as those on pp. 15, 16.

TEGELEN

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Equisetum</i> ..	<i>ramosissimum</i> Desf.	+	+						
<i>Petamogelon</i>	<i>pectinatus</i> L., <i>acutifolius</i> Link. ..	+	+						
	<i>pusillus</i> L., <i>coloratus</i> Hornem. ..								
<i>Najas</i> ..	<i>marina</i> L., <i>minor</i> All.	+	+						
<i>Sagittaria</i> ..	<i>sagittifolia</i> L. ..	+	+						
<i>Alisma</i> ..	<i>plantago</i> L... ..	+	+						
<i>Stratiotes</i> ..	<i>aloides</i> L.	+	+						
<i>Scirpus</i> ..	<i>lacustris</i> L., <i>Tabernaemontani</i> Gmel.	+	+						
<i>Dulichium</i> ..	<i>vespiforme</i> Reid ..				+	+			+
<i>Carex</i> ..	<i>riparia</i> , Curtis, <i>hirta</i> L., <i>echinata</i> , L. ...	+	+						

TEGELEN—continued.

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Pterocarya</i> ..	<i>limburgensis</i> Reid ..				+	+			+
<i>Carpinus</i> ..	<i>betulus</i> L.	+	+						
<i>Alnus</i> ..	<i>viridis</i> Chaix ..	+	+						
<i>Pilea</i> ..	<i>pumila</i> A. Gr. ..				+	+			+
<i>Rumex</i> ..	cf. <i>obtusifolius</i> L., <i>maritimus</i> L., <i>acetosella</i> L.	+	+						
<i>Polygonum</i>	<i>lapathifolium</i> L., <i>Bel-</i> <i>lardi</i> All. ..	+	+						
<i>Chenopodium</i>	<i>urbicum</i> L., <i>rubrum</i> L.	+	+						
<i>Atriplex</i> ..	<i>patula</i> L.	+	+						
<i>Stellaria</i> ..	<i>aquatica</i> Scop., <i>nemo-</i> <i>rum</i> L.	+	+						
<i>Lychnis</i> ..	<i>flos-cuculi</i> L. ..	+	+						
<i>Euryale</i> ..	<i>limburgensis</i> Reid				+	+			+
<i>Ceratophyllum</i>	<i>demersum</i> L. ..	+	+						
<i>Aquilegia</i> ..	<i>vulgaris</i> L. ..	+	+						
<i>Clematis</i> ..	<i>vitalba</i> L. ..	+	+						
<i>Thalictrum</i> ..	<i>Bauhini</i> Crantz ..	+	+						
<i>Magnolia</i> ..	<i>kobus</i> D.C. ..				+	+			+
<i>Mespilus</i> ..	<i>cuneata</i> S. & Z. ..	+		+					+
<i>Phellodendron</i>	<i>elegans</i> Reid ..				+	+			+
<i>Corema</i> ..	<i>intermedia</i> Reid ..	+	+						
<i>Acer</i> ..	<i>campestre</i> L. ..	+	+						
<i>Menispermum</i>	<i>dahuricum</i> D.C. ..				+	+			+
<i>Actinidia</i> ..	<i>faveolata</i> Reid ..				+	+			+
<i>Vitis</i> ..	<i>vinifera</i> L. ..	+	+						
<i>Hypericum</i>	<i>androsaemum</i> L., <i>per-</i> <i>foratum</i> L., <i>pul-</i> <i>chrum</i> L. ..	+	+						
<i>Trapa</i> ..	<i>natans</i> L.	+	+						
<i>Hippomara-</i> <i>thrum</i> ..	<i>sp.</i>	+	+						
<i>Petroselinum</i>	<i>segetum</i> Koch. ..	+	+						
<i>Cicuta</i> ..	<i>virosa</i> L.	+	+						
<i>Laserpitium</i>	<i>siler</i> Murr.	+	+						
<i>Verbena</i> ..	<i>officinalis</i> L. ..	+	+						
<i>Stachys</i> ..	<i>sylvatica</i> L., <i>longi-</i> <i>flora</i> Bois. & Bal.	+	+						
<i>Melissa</i> ..	<i>officinalis</i> L. ..	+	+						
<i>Origanum</i> ..	<i>vulgare</i> L.	+	+						
<i>Thymus</i> ..	<i>serpyllum</i> L. ..	+	+						
<i>Lycopus</i> ..	<i>europaeus</i> L. ..	+	+						
<i>Mentha</i> ..	<i>aquatica</i> L. ..	+	+						
<i>Physalis</i> ..	<i>alkekengi</i> L. ..	+	+						
<i>Solanum</i> ..	<i>dulcamara</i> L. ..	+	+						
<i>Veronica</i> ..	<i>chamaedrys</i> L. ..	+	+						
<i>Valeriana</i> ..	<i>tripteris</i> L. ..	+	+						
<i>Carduus</i> ..	<i>nutans</i> L., <i>palustris</i> Willd.	+	+						
50		42	41	1	8	8	0	0	9
	Per cent.	84	82	2	16	16	—	—	18

PONT-DE-GAIL

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Najas</i> ..	<i>marina</i> var. <i>intermedia</i> A. Br. ..	+	+						
<i>Stratiotes</i> ..	<i>tuberculatus</i> E. M. Reid ..	+	+						
<i>Epipremnum</i>	<i>crassum</i> Reid ..				+	+			+
<i>Carpinus</i> ..	<i>sp.</i> (cf. <i>betulus</i> L.)	+	+						
<i>Betula</i> ..	<i>humilis</i> Schrank. ..	+	+						
<i>Alnus</i> ..	<i>sp.</i> (cf. <i>A. cordifolia</i> Ten.) ..	+	+						
<i>Pilea</i> ..	<i>pumila</i> A. Gr. var. <i>cantalensis</i> E.M.R.				+	+			+
<i>Fagopyrum</i> ..	<i>pliocenicum</i> E. M. Reid ..				+	+			+
<i>Menispermum</i>	<i>cantalense</i> E. M. Reid				+	+			+
<i>Magnolia</i> ..	<i>sp.</i> (cf. <i>salicifolia</i> Maxim.) ..				+	+			+
<i>Cleomella</i> ..	<i>sp.</i> (cf. <i>C. longipes</i> Torr.) ..				+	+			+
<i>Polanisia</i> ..	<i>rugosa</i> E. M. Reid				+		+		+
<i>Sorbus</i> ..	cf. <i>expansa</i> Koehne	+		+					+
<i>Rubus</i> ..	<i>occidentalis</i> L., cf. <i>R. villosus</i> Ait. ..	+		+					+
<i>Prunus</i> ..	<i>venosa</i> Koehne ..	+		+					+
<i>Phellodendron</i>	<i>ornatum</i> E. M. Reid				+	+			+
<i>Ilex</i> ..	<i>cantalensis</i> E. M. Reid (cf. <i>I. coralina</i> , <i>I. subrugosa</i>)	+		+					+
<i>Meliosma</i> ..	<i>europaea</i> Reid ..				+	+			+
<i>Vitis</i> ..	<i>lanata</i> Roxb., <i>V. Thunbergi</i> S & Z.	+		+					+
<i>Actinidia</i> ..	<i>faveolata</i> Reid ..				+	+			+
<i>Hypericum</i> ..	<i>cantalense</i> E. M. R. (cf. <i>H. Drummondii</i> , <i>H. canadense</i>) ..	+		+					+
<i>Acanthopanax</i>	<i>Rehderianus</i> Harms.				+	+			+
<i>Aralia</i> ..	<i>Thomsonii</i> Seem. ..				+	+			+
<i>Symplocos</i> ..	<i>jugata</i> E. M. R., <i>urceolata</i> E. M. R., <i>microcarpa</i> E. M. R.				+		+		+
<i>Ehretia</i> ..	<i>europaea</i> E. M. R...				+	+			+
<i>Clerodendron</i>	<i>sp.</i> (cf. <i>C. serratum</i> Spreng.) ..				+		+		+
<i>Amethystea</i>	<i>coerulea</i> L. ..				+	+			+
<i>Lycopus</i> ..	<i>antiquus</i> E. M. R. (cf. Japanese & American forms)	+		+					+
<i>Solanum</i> ..	<i>dulcamara</i> L. var...	+	+						
<i>Hyoscyamus</i>	<i>niger</i> L. ..	+	+						
<i>Sambucus</i> ..	<i>pulchella</i> Reid (cf. <i>S. chinensis</i> , <i>S. glauca</i>)	+		+					+
<i>Trichosanthes</i>	<i>fragilis</i> E. M. Reid				+	+			+
32		15	7	8	17	14	3	0	25
	Per cent.	47	22	25	53	44	9	0	78

BEMBRIDGE.

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Acrostichum</i>	<i>Lanzaeanum</i> (Vis.)				+		+		+
<i>Azolla</i> ..	<i>prisca</i> n. sp. ..				+		+		+
<i>Equisetum</i> ..	<i>lombardianum</i> Sap.?	+		+					+
<i>Araucarites</i>	<i>gurnardi</i> Florin n. sp. ..				+	+			+
<i>Ottelia</i> ..	<i>britannica</i> n. sp. ..				+		+		+
<i>Stratiotes</i> ..	<i>neglectus</i> Chand. ..	+	+						
<i>Sabal</i> ..	<i>major</i> (Unger) ..				+	+			+
<i>Palaeothrinax</i>	<i>Mantelli</i> n. gen. n.sp.				+	+			+
<i>Epipremnum</i>	<i>ornatum</i> n. sp. ..				+	+			+
<i>Engelhardtia</i>	<i>macroptera</i> Bgt. ..				+	+			+
<i>Ficus</i> ..	<i>sp.</i>	+		+					+
<i>Brasenia</i> ..	<i>ovula</i> Bgt.				+		+		+
<i>Clematis</i> ..	<i>vectensis</i> n. sp. ..	+		+					+
<i>Ranunculus</i>	<i>heterostylus</i> n. sp. ..	+		+					+
<i>Cinnamomum</i>	<i>lanceolatum</i> (Unger), <i>C. Scheuchzeri</i> Heer				+	+			+
<i>Neolitsea</i> ..	<i>sp.</i>				+	+			+
<i>Papaver</i> ..	<i>pictum</i> n. sp. ..	+	+						
<i>Zanthoxylon</i> ?	<i>costatum</i> n. sp. ..				+		+		+
<i>Zizyphus</i> ..	<i>paradisicus</i> var. <i>paradoxa</i> ..	+		+					+
<i>Phyllanthera</i>	<i>vectensis</i> n. sp. ..				+	+			+
<i>Tylophora</i> ..	<i>antiqua</i> n. sp. ..				+		+		+
<i>Melissa</i> ..	<i>parva</i> n. sp. ..	+	+						
<i>Acanthus</i> ..	<i>rugatus</i> n. sp. ..	+		+					+
<i>Catalpa</i> ..	<i>rugosa</i> n. sp. ..				+	+			+
<i>Incarvillea</i> ..	<i>pristina</i> n. sp. ..				+	+			+
<i>Radermachera</i>	<i>pulchra</i> n. sp. ..				+	+			+
<i>Abelia</i> ..	<i>quadrialata</i> , <i>quinquealata</i> , <i>trialata</i> n. spp. ..				+	+			+
<i>Dipelta</i> ..	<i>europaea</i> n. sp. ..				+	+			+
28		9	3	6	19	13	6	0	25
	Per cent.	32	11	21	68	47	21	0	89

HORDLE

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Acrostichum</i>	<i>Lanzaeanum</i> (Vis.)				+		+		+
<i>Salvinia</i> ..	<i>hantoniensis</i> Chand.	+		+					+
<i>Sequoia</i> ..	<i>Couttsiae</i> Heer ..				+	+			+
<i>Stratiotes</i> ..	<i>headonensis</i> Chand.	+	+						
<i>Nipa</i> ..	<i>sp.</i>				+	+			+
<i>Chlorophora</i>	<i>bicarinata</i> Chand.				+		+	+	
<i>Broussonetia</i>	<i>rugosa</i> Chand. ..				+	+			+
<i>Orites</i> ..	<i>sp.</i>				+	+			+

HORDLE—continued.

Genus.	Species.	A	A'	A''	B	B'	B''	B'''	C
<i>Brasenia</i> ..	<i>oblonga, antiqua, spinosa</i> , spp. Chand.				+		+		+
<i>Menispermum</i>	<i>obliquatum</i> Chand.				+	+			+
<i>Corydalis</i> ..	<i>pulchrum</i> Chand. ..	+		+					+
<i>Rubus</i> ..	<i>acutiformis</i> Chand.	+		+					+
<i>Zanthoxylon</i>	<i>ornatum, compressum</i> spp. Chand. ..				+		+		+
<i>Phellodendron</i>	<i>costatum</i> Chand. ..				+	+			+
<i>Natsiatum</i> ..	<i>eoenicum</i> Chand. ..				+	+			+
<i>Iodes</i> ..	<i>sp.</i>				+		+		+
<i>Tetrastigma</i>	<i>lobata</i> Chand. ..				+	+			+
<i>Parthenocissus</i>	<i>sp.</i>				+	+			+
<i>Ampelopsis</i> ..	<i>rotundata</i> Chand. ..				+	+			+
<i>Actinidia</i> ..	<i>crassisperma</i> Chand.				+	+			+
<i>Gordonia</i> ..	<i>minima</i> Chand. ..				+	+			+
<i>Mastixicarpum</i> ..	<i>crassum</i> Chand. ..								
<i>Eomastixia</i>	<i>bilocularis</i> Chand. ..				+	+			+
<i>Diospyros</i> ..	<i>antiqua</i> Chand. ..	+		+					+
<i>Symplocos</i> ..	<i>headonensis</i> Chand.				+		+		+
<i>Styrax</i> ..	<i>elegans</i> Chand. ..	+		+					+
<i>Omphalodes</i>	<i>platycarpa</i> Chand.	+	+						
<i>Sambucus</i> ..	<i>parvulus</i> Chand. ..	+		+					+
27		8	2	6	19	13	6	1	24
	Per cent.	30	8	22	70	48	22	3	89

VII. THE RELATION OF THE EXISTING FLORA OF S.W. CHINA AND UPPER BURMA TO EUROPEAN TERTIARY FLORAS

These regions "until comparatively recently were totally unknown to the outside world. The botanical collections of the . . . Abbés David and Delavay, of the Russian traveller N. M. Prewalski, and of the Imperial Maritime Customs Officer, Augustine Henry, gave the first true insight into the extraordinary richness of the flora of Central and Western China." So writes Mr. E. H. Wilson (1913, vol. ii, p. 4), the Assistant Director of the Arnold Arboretum. Mr. Wilson is himself one of the most distinguished contributors to our knowledge of the flora of these regions; and his immense collections of woody plants have furnished the material for the "Plantae Wilsonianae" of Prof. C. S. Sargent (1911-17).

More lately, very extensive additions to our knowledge have been made by the English botanists and travellers, Messrs. George Forrest, Reginald Farrer, and Kingdon Ward, and by Dr. Handel-Muzzetti, of Vienna. Yet even so, year by year, as these explorers go into the field, they bring back fresh treasures from these marvellous stores.

In the face of such an advance in knowledge of a flora so closely allied to the Tertiary floras of Europe—an advance which has taken place very largely within the last thirty-five years, or even within the present century—it is small wonder that the classic work of Unger, Heer, von Ettingshausen, de Saporta, Schimper, and others, who laid down so magnificently the foundations of Tertiary palaeobotany, should require revision where critical questions of species, and consequently of floral relationships, are concerned.

These recent explorations have not only increased our knowledge by the discovery of new genera such as *Fokientia*, *Sinowilsonia*, *Fortuneria*, *Sinofranchetia*, *Sargentodoxa*, *Kolkwitzia*, and *Beesia*, to name a few, and by the discovery of countless new species; they have also proved the existence in China of genera represented on the American continent—*Liriodendron*, *Sassafras*, *Carya*, and others; they have proved the extension of genera, and even of species, formerly regarded as tropical, into more temperate regions of latitude or altitude; and finally they have furnished information of the utmost importance concerning many of the genera forming part of the Tertiary flora of Europe.

We may illustrate the last two points. In respect of the discovery of tropical genera and species in the temperate forests of China, the following are among those of which we have taken note in the course of our work:

Epipremnum, a genus known, as Engler states (1889, p. 120), from the Malayan region only, but of which Prof. A. Henry records species from 4500 feet (Henry, No. 11,720A), 5000 feet (Henry, No. 12,728), in the mountain forests of Yunnan, and another large climbing species (Henry, No. 11,216) from 7000 feet, also in the forests of Yunnan.

Clerodendron serratum Spreng., usually a tropical genus, and stated in the "Pflanzenfamilien" to be a native of Further India, has been recorded by Prof. Henry (Nos. 12,482 and 10,077B) from the mountains of Yunnan at heights of 5000 feet.

Buchanania latifolia Roxb., a tropical plant in various parts of the Far East, was found by Prof. Henry in the mountain forests of Yunnan at heights of 5000 feet (Nos. 12,639 and 13,158).

Bucklandia populnea R. Br., known from Sumatra, Java, the Eastern Himalaya, and the Khasia Mountains, is recorded by Mr. Kingdon Ward up to heights of 8000 feet in Upper Burma. Mr. Ward states (1921, pp. 36, 74) that it grows in association with *Schima*, oak, *Ficus*, *Acer*, *Magnolia*, and many other trees; and by letter he informs us that he has found it with "*Betula* and *Picea* . . . on the same mountain side separated perhaps by 1500 feet of altitude."

We draw attention to this new knowledge of the distribution of certain plants because it has such important bearings on the

question of past climates, and it is a point which has sometimes been overlooked (Laurent, 1923, p. 57).

To show the importance of the botanical exploration of China and Burma on the study of Tertiary plants we may give the following illustrations :

In 1861 Heer gave (p. 55) the distribution of all the genera of living Juglandaceae known to him as follows :

<i>Juglans</i>	..	..	..	Persia, North America
<i>Carya</i>	..	..	..	America
<i>Pterocarya</i>	..	..	..	Caucasus
<i>Engelhardtia</i>	..	..	..	Sunda Islands.

Since this was written the following additions have been made to the knowledge of the family :

Juglans. Several species are now known from China. And, further, the " original home [of *J. regia* L.] is now believed to be on the mountains of Northern and Western China " (C. S. Sargent in Wilson, 1913, p. xx).

Carya is now known from China and Indo-China by the species *C. cathayensis* Sargent, and *C. tonkinensis* Lecomte.

Pterocarya is now known by many species from China and two from Japan, often with fruits differing greatly both from one another and from *P. caucasica*.

Engelhardtia is now known from the Himalayas, Japan, China (several species), Formosa, Burma, the Malay Peninsula, and the Philippines, being represented by at least twelve species.

Platycarya. This genus inhabiting Japan and China, although first described in 1843, appears to have been unknown to Heer.

Oreomunnea. This genus from eastern North America, which was described in 1856, appears also to have been unknown to Heer.

In 1866 de Saporta gave the distribution of *Liriodendron* as North America. Since 1875 it has been known to be also a native of China.

In 1885 Renault, following Schimper, gave the distribution of *Libocedrus* as New Zealand, the Andes of Chili, Oregon, and California. *L. macrolepis* from China is now known, and several species from New Guinea.

Of another genus constantly recorded fossil, *Magnolia*, Prof. Sargent (1911-17) enumerates twenty-five species from Asia, of which ten are endemic to S.W. China.

Of other genera which have been recorded fossil, *Rubus*, *Prunus*, *Cotoneaster*, *Acer*, *Styrax*, *Symplocos*, *Meliosma*, *Cornus*, *Acanthopanax*, *Salix*, *Rhododendron*, and even *Fagus* (1 species), to name some among the woody plants, have within the last few years been enriched by many new species from South-West and Central China. In some cases, such as *Prunus* and *Salix*, the

number of new species is very great, and in *Rhododendron* can only be numbered in hundreds.

The lists might be greatly prolonged, but these examples suffice to show what important bearings the botanical exploration of China and Burma may have on the determinations and conclusions of early workers. So far as the knowledge of the times permitted, the East Asian alliance was recognised by these pioneers (Heer, 1861, pp. 58-60, and Saporta, 1879, pp. 370-373), but its full extent was not, and could not, then be known.

We do not think we do injustice to the work and memory of these distinguished men if we suggest that their determinations and conclusions should be most carefully scrutinised in the light of the new knowledge of the floras of the Far East.

VIII. THE RELATION OF THE BEMBRIDGE FLORA TO OTHER FOSSIL FLORAS

We propose to compare the Phanerogams of the Bembridge flora with those of the following fossil floras: Monte Promina (Ettingshausen, 1854), Häring (Ettingshausen, 1853), Amber Beds of Samland (Conwentz, 1886), Hordle (Chandler, 1925), Bovey Tracey (Heer, 1862*a*; C. & E. M. Reid, 1910*a*), Aix en Provence (Saporta, 1872, 1873, 1888*a*, 1889), Armissan (Saporta, 1865), St. Zacharie (Saporta, 1863), St. Jean de Garguier (Saporta, 1865), Sotzka (Unger, 1851, Ettingshausen, 1858), Célas (Laurent, 1899), Pont-de-Gail (E. M. Reid, 1920*b*, 1923), Reuver (C. & E. M. Reid, 1915), Schosnitz (Kräusel, 1920, 1921), Tegelen (C. & E. M. Reid, 1907, 1910). These cover a large range in time both before and after the Bembridge Period. Some present coincidences in species with Bembridge species. There is also a variety in the manner of fossilisation.

There are two methods which suggest themselves for comparing fossil floras. The first, the one most usually followed, is to compare the individual components, approximating in age those floras which offer most points of similarity. The method is of value when neither local edaphic nor climatic conditions, nor different modes of preservation (see pp. 10-13) have rendered the floras little comparable, and when they are of the same size. But difference in size introduces, as will readily be seen, an error in the comparison. For if two fossil floras A and B are compared with a third C, all being of the same age, grown under similar conditions, and similarly fossilised, but A being larger than B, it is obvious that A has a greater chance—a chance in considerable degree proportional to its size—of being represented in C. A true comparison should therefore take cognisance of the size of the floras compared.

In the table below is shown the distribution of Bembridge species, or of very closely allied species, throughout the floras

we have named. The correspondences are too few, and some of the species have too wide a range in time, to be of much use, so it appears to us, in placing the Bembridge flora with any certainty in relation to these others.

TABLE III

LIST OF BEMBRIDGE SPECIES WHICH OCCUR IN ANY OF THE ABOVE FLORAS

(Comparable and doubtful species in *italics*.)

	Monte Promina.	Håring.	Hordle.	Bovey Tracey.	Sotzka.	Célas.	Armissan.	St. Zacharie.	St. Jean de Garguer.	Aix.
<i>Araucarites gurnardi</i> (cf. <i>A. Sternbergii</i>)	(+)	(+)			(+)	(+)				
<i>Sequoia Couttsiae</i> [?] ..			+	+			+			
<i>Sabal major</i>						+			+	+
<i>Palaeothrinax Mantelli</i> (cf. <i>Flabellaria Lamanonis</i>)	(+)	(+)			(+)					(+)
<i>Typha latissima</i>										+
<i>Potamogeton pygmaeus</i> ..			+							
<i>Limnocarpus headonensis</i>			+							
<i>Spirematospermum Wetz-</i> <i>leri</i>			+	+						
<i>Brasenia ovula</i>			+	+						
<i>Rhamnospermum bilobatum</i>			+							
<i>Engelhardtia macroptera</i>					+		+			
<i>Hooleya Hermis</i>					+					
<i>Cinnamomum lanceolatum</i>	+	+			+		+	+	+	+
„ <i>Scheuchzeri</i>										+
<i>Zizyphus paradisiacus</i> var. <i>paradoxus</i> (cf. <i>Z. paradisi-</i> <i>siacus</i>)					+	+				+

There is, however, a point which emerges, and one worth noting, namely, the influence of mode of fossilisation on the occurrence of species. Hordle (a seed-bed), and to some extent Bovey (also partly a seed-bed), show one set of correspondences. The leaf-beds show another, and the amber-beds, which are yet differently preserved, show no correspondence at all, although the flora is a large one and probably near in age to the Bembridge beds.

The second method of comparison is based on the biogeographical relationships of the components of the floras. Such relationships are the outcome of the various influences which, acting upon plant life, produce regional floras—influences so fundamental, that they operate on all species in every flora, although not on all in the same manner ; but yet in such measure that their effect is traceable in every species. The influences we have in mind are those of evolution and dispersion, together with climatic

and orographic changes. These acting on floras produce change in genera and species, migration, regional survival or elimination, and often complete extinction. They stamp their effects in such a manner that every regional flora expresses the summation of them all. Such floras are the palimpsests on which the history of the past is written. This is true whether the flora be living or fossil. Or, to change the metaphor, the fossil flora is but an earlier chapter in a book, of which the living flora is the last. The whole book, chapter by chapter, is in organic sequence from beginning to end. It seems, therefore, justifiable, by ascertaining as accurately as possible the links which unite fossil floras with the living, to trace the course of the history which has resulted in the regional floras of to-day.

In the course of our present study of the Bembridge plants we have seen that the introduction of living European genera into Tertiary Europe was progressive (pp. 16-18). This progressive introduction, the division of genera into European and non-European, offers the simplest subject for investigation along the lines we speak of. Yet even so, it is by no means easy to assign to each genus its rightful place. Was the fossil evidence sufficient to justify any conclusive opinion as to the alliance? In cases like *Andromeda*, *Vitis*, etc., were they strictly the European genera indicated, or rather the closely allied non-European genera, *Leucothoë*, *Ampelopsis*, *Parthenocissus*, etc.? Again, it was found impossible to disentangle collective genera such as *Leguminosites*, *Phyllites*, *Cypselites*, *Carpolithus*, and so forth. Also the variety of authorship introduces a difference in the personal equation, which may influence the proportion of genera determined in the different floras, and may make the determinations of unequal value. In short, the attempt is hampered by many difficulties and shortcomings, and can only be considered very approximate. Nevertheless, such as it is, we give it.

There is a slight difference in the present classification from that given on p. 16. There, being chiefly concerned in sifting the genera with European affinity from those with East Asian and North American affinity, we omitted those (very few) which have close alliance with plants growing in both regions. Here we retain them. We also omitted all genera for which the *specific* alliance was uncertain. Here we include them. In the present instance, too, we omit all Cryptogams. The results of these differences are seen in a slightly higher percentage of European genera for Hordle (31 per cent. instead of 30 per cent.); and higher percentages for Bembridge and Tegelen (38 per cent. and 87 per cent., as against 32 per cent. and 84 per cent.); Pont-de-Gail remains unaltered.

Having made the division of genera in the various floras, we then find what percentage of the determined part of each is European. The following list gives the results. These, as we

have already said, are merely approximate to the truth. Whilst taking much on trust, we have had, as we have already stated, to use our judgment in the matter, of what to include, what to exclude. Doubtless, as more and more of the doubtful and unknown forms are resolved, the percentage of European genera would diminish; for it is probable that the majority of these are non-European.

Beginning at the lowest percentage (and oldest), they are as follows:

Monte Promina, 24	Bembridge, 38
Häring, 30	Bovey Tracey, 38 (uncertain)
Hordle, 31	Célas, 41
Amber-beds, 35	Aix, about 44 (uncertain)
Sotzka, about 36 (uncertain)	Pont-de-Gail, 47
St. Jean de Garguier, 37	Schosnitz, 52
Armissan, 37.5	Reuver, 58
St. Zacharie, 38	Tegelen, 87

The greater age of Monte Promina appears in its having the lowest percentage of European genera; the younger age of Pont de Gail, Schosnitz, Reuver, and Tegelen in their high percentages.

If Hordle, of which the stratigraphical position is clear, be regarded as representing the top of the Eocene, and Bembridge as either at the base of the Stampian (Middle Oligocene) or top of the Sannoisian (Lower Oligocene), then the others occupy positions which by one or another author have been suggested for them. The most marked exceptions are: Sotzka, said to be of Aquitanian Age, which shows a percentage too low (*i.e.* making it too old), and Aix, regarded by de Saporta as Eocene, but placed by others in the Stampian, and by de Lapparent between the Stampian and Sannoisian, with a percentage too high (making it too young). It may be remarked that the low percentage of Pont-de-Gail is more in keeping with a Miocene Age than with the Lower Pliocene, to which it was at first referred; but even so it appears rather low.

IX. CLIMATE

The question of climate can only be treated in a very general way when dealing with extinct species. It is not justifiable to lay too much stress on individuals: for whatever be the present habitat and climatic zone of the nearest allies, it can never be known with certainty that this was exactly shared by the fossils; although the probability that it was so for the majority of species is great. Yet even among allied living species we find often a variety in climatic preference; and many individual species have wide range.

It is only possible to take the general indication of an assemblage of plants, noting those species which appear to be at all aberrant.

In the Bembridge flora the general indication is of plants inhabiting warm temperate and subtropical regions, as will appear in the course of the detailed study of the species. The indications of such a climate are fairly uniform. The plants with European alliance, *Melissa* and *Stratiotes*, possibly show the coolest element; but these are not living species, and may only indicate plants which by specific changes have been able to adapt themselves to cooling conditions. *Acrostichum*, *Acanthus*, and *Phyllanthera*, would appear to represent the warmest element; and the *Acrostichum* is exceedingly close to the living *A. aureum*. We cannot pretend to explain such discrepancies. We can only state them.

X. REMARKS ON A FEW SPECIAL GENERA AND SPECIES

A few genera and species call for special mention.

Stratiotes is now a monotypic genus confined to Europe and Western Siberia, and mainly to Central Europe. Its geological history has been traced from the Upper Eocene of Hordle to the present day through a succession of species (Chandler, 1923). Except at one period (Middle Oligocene), when it is represented by two species in the Hamstead beds, it has remained, so far as our evidence goes, monotypic at any given time. It is unknown in the fossil state outside Europe. Such a history seems to indicate the evolution of the genus (an aquatic one) within the confines of Europe itself.

Papaver pictum n. sp. (cf. *P. rupifragum* Boiss. & Reut.). This appears to hold the same position in the Bembridge flora as is held by *Omphalodes platycarpa* Chandler in the Hordle flora. Each finds its nearest ally in a Spanish species (*P. rupifragum* occurs also in Morocco), and each belongs to a genus dispersed throughout Central and Southern Europe and the Near East, though each ranges also to China, and *Omphalodes* reaches Mexico. It may be that in these links between the West European Tertiary floras and the flora of Spain, we catch a glimpse of a stage in the European history when, before the transcontinental mountain barrier was as important as it afterwards became, Spain received some of the elements of her flora in common with other parts of Europe. Later, when the barrier of mountains interposed, these species were trapped in Spain, where they lived on, but were exterminated in the north.

Sparganium. The Bembridge flora has added another link, and that the earliest, to our knowledge of the fruits of *Sparganium*. *S. multiloculare*, belonging to this flora, shows 5-4-3-2-loculed fruits. *S. ovale*, from Pont-de-Gail (Reid, 1920b), showed frequently 2-loculed fruits. Dr. Hartz (1909, p. 126) recorded an interglacial form of *S. ramosum* with 4-3-2-locules. In the living genus only two species, *S. Greenei* and *S. eurycarpum*, normally

show more than one, though *S. ramosum* occasionally does so. The fossil evidence therefore suggests that the normal occurrence of 1-locule has been brought about by reduction. It has been suggested in a paper on the genus *Sparganium* that the contrary was the case; that "the solitary uni-ovulate carpel is probably the most primitive type among the monocotyledons, and is not the result of reduction" (Campbell, 1899). In *Sparganium* the geological evidence is clearly against such an idea. The multi-locular fruit affords also a valuable and interesting link between *Sparganium* and Pandanaceae.

Hooleya Hermis (Ung.). In this inferior 2-winged fruit, with its pair of styles and discoid glandular papillae, we have undoubtedly a well-characterised addition to the family Juglandaceae. It is either extinct or unknown living. In the nervation of its wings it resembles *Pterocarya*, especially the 2-winged species *P. Forrestii* W. W. Sm. But in all species of *Pterocarya* the fruit is globose, and the wings are usually flattened in the equatorial plane, though to this *P. stenoptera* with wings twisted and flattened in a vertical plane is somewhat of an exception. Flat fruits having small wings flattened in the vertical plane are found in *Platycarya*, but in this the wings are so small as scarcely to be more than rims.

Azolla. The fossil specimens of *Azolla* show evidence as full and indisputable as that afforded by living specimens. They represent an extinct form combining characters which are now used to differentiate the living genus into two groups. These characters are—massulae with glochidia, found in the section *Euazolla*; and macrosporangia with nine floats arranged in triplets, found in the section *Rhizosperma*.

Section *Euazolla* is native of Australia, New Zealand, Tasmania and America.

Section *Rhizosperma* is native of Japan, E. India, Ceylon, New Guinea, Australia, also Africa and Madagascar.

It is evident that the Bembridge species of *Azolla* is more closely related to the two sections than these are to one another. Also it exhibits every character of both, except such as could be acquired by reduction. It must therefore belong to an earlier evolutionary stage than these.

XI. LIST OF BEMBRIDGE SPECIES

Species marked by an asterisk are those previously described and figured, which appear to be correctly determined, but which are now lost.

CHAROPHYTA :

Chara medicaginula (Lamarck)
helicteres Brongniart.
tuberculata Lyell.
vasiformis Reid & Groves.
vespiformis Groves, n. sp.

- CHAROPHYTA : *Chara subglobosa* Groves, n. sp.
perpusilla Groves, n. sp.
vectensis Groves, n. sp.
- FILICALES : *Acrostichum Lanzaeanum* (Visiani).
Azolla prisca n. sp.
- EQUISETALES : *Equisetum lombardianum* Saporta.
- CONIFERALES : *Araucarites gurnardi* Florin, n. sp.
Doliosstrobos sp. (*Araucarites gurnardi* ?)
 * *Pinus Dixoni* Bowerbank.
 * *vectensis* Gardner.
 spp. 1 & 2.
Pityospermum ambiguum n. sp.
Cupressus sp.
 ? *Libocedrus* sp.
- MONOCOTYLEDONES : *Typha latissima* Al. Braun.
Sparganium multiloculare n. sp.
Potamogeton pygmaeus Chandler.
 spp. 1 & 2.
Limnocarpus headonensis (Gardner).
spinosus n. sp.
Najas oligocenica n. sp.
Ottelia britannica n. sp.
Stratiotes neglectus Chandler.
Carex gurnardi n. sp.
 ? sp. 2.
Cladiocarya foveolata n. gen et sp.
Sabal major (Unger).
Palaeothrinax Mantelli n. gen. et sp.
Palmophyllum sp.
Epipremnum ornatum n. sp.
Spirematospermum Wetzleri (Heer).
Costus sp.
Monocotylophyllum sp.
- DICOTYLEDONES : *Engelhardtia macroptera* (Brongniart).
 sp.
Hooleya Hermis (Unger) n. gen.
Carpinus sp.
Fagus sp. ?
Quercus sp. ?
Ficus sp.
Brasenia ovula (Brongniart).
Clematis vectensis n. sp.
Ranunculus heterostylus n. sp.
Cinnamomum lanceolatum (Unger).
Scheuchzeri Heer.
Neolitsea sp.
Papaver pictum n. sp.
Aldrovanda intermedia n. sp.
Zanthoxylon ? *costatum* n. sp.
Zizyphus paradisiacus (Unger) var. *para-*
doxus n.

- DICOTYLEDONES : *Rhamnospermum bilobatum* Chandler.
Apocynospermum striatum n. gen. et sp.
 rostratum n. sp.
 elegans n. sp.
 dubium n. sp.
Phyllanthera vectensis n. sp.
Tylophora antiqua n. sp.
Melissa parva n. sp.
Ajuginucula Smithii n. gen. et sp.
Catalpa rugosa n. sp.
Radermachera pulchra n. sp.
Incarvillea pristina n. sp.
Acanthus rugatus n. sp.
Abelia quadrialata n. sp.
 quinquealata n. sp.
 trialata n. sp.
 sp.
Dipelta europaea n. sp.
Flabelllicula anglica n. gen. et sp.
Samaravectis ovalis n. gen. et sp.
Carpolithus actinidiformis n. sp.
 spp. 2-14.
Dicotylophyllum pinnatifidum n. sp.
 spp. 2-16.
Phyllites sp.

In addition, there are six undetermined species of Filicales, one of Coniferales, three of Gramineae, and one each of Zingiberaceae, Cruciferae, and Compositae, making in all 121 species, not including petals, roots, rhizomes, scars and cuticle fragments.

The following species have been previously determined or recorded on evidence, which in our opinion is insufficient : .

- Lygodium* sp.
Sequoia Couttsiae Heer.

TABLE SHOWING DISTRIBUTION OF LIVING ALLIES

Distribution of living Genera													Name and Distribution of nearest living allies.	
Europe.		Africa.		Asia.				Austra- lasia.	America.					
Europe, excl. of Mediter- ranean.	Mediterranean and Wes- tern Asia.	N. Africa, Canaries, etc.	South and Tropical Africa Mascarene Islands.	India and Ceylon.	N. China, Amur and Japan.	E. Himalaya, S.W. China, Upper Burma, Formosa.	Indo-Malaya, E. Indies.	Australia, N. Zealand, Tasmania.	East North America.	West North America.	Central America and Mexico.	West Indies.		South America.
<i>Acrostichum Lancesanum</i> (Vis.)	..	+	++	++	+	++	+	++	++	+	++	+	++	<i>A. aurcum.</i> genus <i>Azolla</i> .
<i>Azolla prisca</i> n. sp. . .	..	+	+	+	+	++	++	++	+	+	+	+	++	<i>E. giganteum</i> , S. America and W. Indies
<i>Equisetum lombardianum</i> Sap.	+	+	+	+	+	++	++	++	+	+	+	+	++	<i>L. decurrens</i> , West N. America, and more remotely <i>L. macrolepis</i> , China.
<i>Libocedrus</i> sp. . . .	..	..	..	..	..	++	++	..	..	..	+	..	..	various species with small cones.
<i>Cupressus</i> sp. . .	+	+	+	+	..	..	+	++	+	+	+	+	++	genus <i>Araucaria</i> .
<i>Araucarites gurnardi</i> Florin	+	+	+	+	..	..	+	++	+	+	+	+	++	leaves and fruits of <i>T. elephantina</i> , Medi- teranean and E. Indies, also fruits of <i>T. javanica</i> .
<i>Typha latissima</i> Al. Br. . .	+	+	+	+	..	..	..	+	+	+	+	+	+	<i>S. Grenci</i> and <i>S. curycarpum</i> (N. America).
<i>Sparganium multiloculare</i> n. sp.	+	+	..	+	+	..	..	+	+	+	+	+	+	<i>P. cristatus</i> , China and Japan, has spines.
<i>Potamogeton pygmaeus</i> Chand.	++	++	++	++	++	++	++	++	++	++	++	++	++	genus <i>Najas</i> .
<i>Najas oligocenica</i> n. sp. . .	++	++	++	++	++	++	++	++	++	++	++	++	++	genus <i>Ottelia</i> .
<i>Ottelia britannica</i> n. sp. . .	++	..	..	..	..	..	..	..	..	..	..	..	..	<i>S. aloides</i> only living species.
<i>Stratiotes neglectus</i> Chand.	++	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Carex</i> .
<i>Carex gurnardi</i> n. sp. . .	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Sabal</i> .
<i>Sabal major</i> (Ung.) . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Thrinax</i> , Florida and W. Indies.
<i>Palaeothrinax Montellin</i> gen. n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Epipremnum</i> , China, Formosa, Malay Peninsula, E. Indies, Philippines, Australia.
<i>Epipremnum ornatum</i> n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Costus</i> .
<i>Costus</i> sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Engelhardtia</i> ; cf. also genus <i>Oreo-</i> <i>munnea</i> , E. North America.
<i>Engelhardtia macroptera</i> (Brongn.)	..	..	..	..	..	..	..	..	..	..	..	..	..	genus <i>Carpinus</i> .
<i>Carpinus</i> sp. . . .	++	..	..	..	++	..	..	..	++	..	+	..	..	genus <i>Fagus</i> .
<i>Fagus</i> sp. . . .	++	++	..	..	++	..	..	..	++	..	..	..	..	genus <i>Quercus</i> .
<i>Quercus</i> sp. . . .	++	++	++	..	++	..	..	..	++	..	..	..	..	<i>Ficus gibbosa</i> , Sikkim, China and Malay Peninsula.
<i>Ficus</i> sp. . . .	..	+	+	+	+	+	+	+	..	..	..	..	+	<i>Brasenia peltata</i> only living species.
<i>Brasenia ovula</i> (Brongn.) . .	+	+	+	+	+	+	+	+	+	+	+	+	+	<i>C. heracleifolia</i> , China, <i>C. lasiantha</i> , N. America.
<i>Clematis vectensis</i> n. sp. . .	+	+	+	..	+	+	..	+	+	+	+	+	+	<i>R. crassipes</i> and <i>R. rivularis</i> , New Zealand.
<i>Ranunculus heterostylus</i> n. sp.	+	+	..	+	+	+	..	+	+	+	+	+	+	<i>C. pedunculatum</i> Nees, var. <i>angustifolium</i> Hemsl., Yunnan and W. China.
<i>Cinnamomum lanceolatum</i> (Ung.)	..	..	..	..	+	+	+	..	..	..	..	..	..	genus <i>Cinnamomum</i> .
<i>Cinnamomum Scheuchzeri</i> Heer.	..	..	..	++	++	++	++	..	..	..	..	..	..	genus <i>Neolitsea</i> .
<i>Neolitsea</i> sp. . . .	..	..	..	++	++	++	++	..	..	..	..	..	..	<i>P. rupifragum</i> , Spain and Morocco.
<i>Papaver pictum</i> n. sp. . .	++	+	+	+	+	+	+	+	+	+	+	+	+	<i>A. vesiculosa</i> only living species.
<i>Aldrovanda intermedia</i> n. sp.	++	+	+	+	+	+	+	+	+	+	+	+	+	genus <i>Zanthoxylon</i> .
<i>Zanthoxylon costatum</i> n. sp.	..	..	+	+	+	+	+	+	+	+	+	+	+	<i>Z. glabratum</i> , East Asia.
<i>Zizyphus paradisiacus</i> var. <i>paradoxus</i> n. var. . .	..	+	+	+	+	+	+	+	+	+	+	+	+	<i>P. perakensis</i> , Malay Peninsula.
<i>Phyllanthus vectensis</i> n. sp.	..	..	+	+	+	+	+	+	..	..	..	+	..	<i>T. hirsuta</i> , East Indies.
<i>Tylophora antiqua</i> n. sp. . .	..	+	+	+	+	+	+	+	..	..	..	+	..	<i>Melissa officinalis</i> , Europe, N. Africa, Orient.
<i>Melissa parva</i> n. sp. . .	+	+	+	+	+	+	+	+	+	+	+	+	+	<i>A. ilicifolia</i> , East Asia and Australia.
<i>Acanthus rugatus</i> n. sp. . .	+	+	+	+	+	+	+	+	+	+	+	+	+	<i>C. Kaempferi</i> , Japan.
<i>Catalpa rugosa</i> n. sp. . .	..	..	..	..	..	++	++	..	..	..	..	..	..	<i>R. glandulosa</i> , Malay Peninsula and Java.
<i>Radermachera pulchra</i> n. sp.	..	..	..	..	..	++	++	..	..	..	..	..	..	<i>R. sinica</i> , China, Formosa.
<i>Incarvillea pristina</i> n. sp. . .	..	..	..	..	..	++	++	..	..	..	..	..	..	<i>I. grandiflora</i> , Western China.
<i>Abelia quadrialata</i> n. sp. . .	..	..	..	..	..	++	++	..	..	..	..	..	..	various species of China.
" <i>quinquealata</i> n. sp. . .	..	..	..	..	..	++	++	..	..	..	..	..	..	<i>A. chinensis</i> and <i>A. spathulata</i> , China.
" <i>trialata</i> , n. sp. . .	..	..	..	..	..	++	++	..	..	..	..	..	..	<i>A. corymbosa</i> , Turkestan and Baluchistan.
<i>Dipelta europaea</i> n. sp. . .	..	..	..	..	..	..	..	..	..	..	..	..	..	<i>D. yunnanensis</i> , Yunnan (China).



SYSTEMATIC DESCRIPTION

UNLESS there is a definite statement to the contrary, all plants catalogued are from the Bembridge Marl of Gurnard Bay and Thorness Bay, Isle of Wight, and were collected by A'Court Smith.

The descriptions, where based on impressions or casts, are of the object itself as inferred from the impression, not of the impression as seen, unless otherwise stated. Thus pits on the surface of an impression are interpreted, and described, as tubercles on the original, and so forth.

Species previously described and figured, which appear to be correctly determined, but cannot now be traced and have therefore not been seen by us, are marked by an asterisk. •

Names which have been attached to certain specimens on evidence which, in our opinion, is insufficient are followed by [?].

PTERIDOPHYTA

Order FILICALES

Family POLYPODIACEAE

Genus ACROSTICHUM Linnaeus

1753 *Acrostichum* (partim): Linnaeus, Spec. Pl., ed. 1, p. 1067.

1845 *Chrysodium*: Fée, Hist. d'Acrost. p. 22.

1906 *Acrostichum*: Christensen, Index Filicum, p. liii.

Acrostichum Lanzaeanum (Visiani)

Plate I, figs. 1-5; text-fig. 1.

1858 *Fortisia Lanzaeana* Visiani, *Mem. Ist. Ven.*, vii, p. 431, pl. i, fig. 8, pl. ii, figs. 1, 5.

1879 *Chrysodium Lanzaeanum* (Vis.): Gardner & Ettingshausen, *Eocene Flora*, i, p. 26, pl. i, pl. ii, figs. 1-4.

1886 *Chrysodium Lanzaeanum* (Vis.): Gardner, *Rep. Brit. Ass.* (1885), p. 402, pl. iii, fig. 5.

1888 *Chrysodium minus* Saporta, *Ann. Sci. Nat. Bot.* (7), vii, p. 20, pl. ii, fig. 3.

1888 *Chrysodium dilaceratum* Saporta, *op. cit.* p. 18, pl. ii, figs. 4, 5.

- 1890 *Chrysodium splendidum* Saporta, *Rev. Gén. Bot.*, ii, p. 227, pl. xii, fig. 1.
 1899 *Chrysodium Lanzaeanus* (Vis.): Laurent, *Ann. Mus. Hist. Nat.*, Marseille (2), i, p. 55, pl. i, fig. 10.
 1924 *Acrostichites* sp. cf. *A. Lanzaeanus* (Vis.): Seward, *Bull. Geol. Surv. Nigeria*, no. 6, p. 67, pl. i, fig. 1.
 1925 *Acrostichum* (*Chrysodium*) *Lanzaeanum* (Vis.): Chandler, *Upper Eocene Flora*, p. 10.

DIAGNOSIS: Fronds compound pinnate, sub-stipitate, coriaceous, margin entire; secondary nerves forming a coarse network of quadrilateral, hexagonal, or lozenge-shaped meshes; free veinlets absent. Fructification unknown. Sterile fronds of the type seen in *Acrostichum aureum* Linn.

DESCRIPTION: Pinnae coriaceous, lanceolate to oblong, varying considerably in form and size, narrowed gradually to the base; apex missing; margin entire. Midrib broad, prominent on the lower side, flat or channelled on the upper; secondary nerves arising from the midrib at sharp angles, then curving outwards,

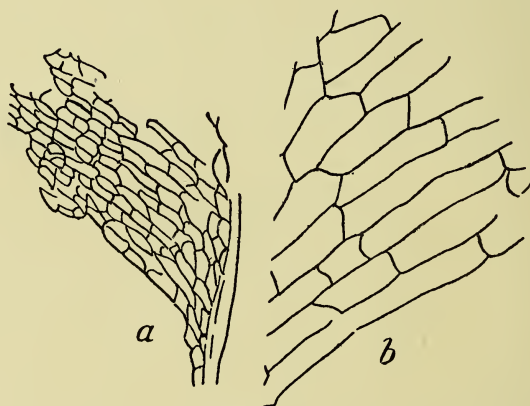


FIG. 1.—*Acrostichum Lanzaeanum* (Vis.). Camera lucida drawing to show variation in coarseness of nervation. *a*, V.17672; *b*, V.17673, $\times 3$.

anastomosing all over the surface to form a network of quadrilateral, hexagonal, or lozenge-shaped meshes varying greatly in the degree of coarseness in different specimens (text-fig. 1), meshes adjoining the midrib elongate longitudinally, free veinlets absent. Surface rough on the lower side of the leaf, smooth on the upper, but with close-set shallow polygonal depressions; midribs and nerves show indefinite longitudinal crumplings; cell-structure not visible.

Length of pinnae always incomplete; greatest breadth 40 mm. Impressions of pinnae (both surfaces) numerous, but very

fragmentary and often torn and twisted as though they had drifted before sinking into the mud.

AFFINITIES : The Bembridge species is identical in form (so far as can be seen) and in nervation with specimens from the Lower Haddon of Hordle in the Sedgwick Museum, Cambridge. These have never been described, and two of them are now figured (Pl. I, figs. 4, 5) for comparison with the Bembridge fossils. Thanks to their more perfect condition, they give a better idea of the species than can be obtained from the fragmentary Bembridge material; thus one specimen (Pl. I, fig. 4) shows that the fronds were compound, pinnate with sub-stipitate pinnae gradually narrowing into the rachis. They display the same variation in the secondary nervation as the Bembridge fossils, and similar distinctions between the upper and lower leaf-faces.

Among the Hordle specimens, actual fronds (somewhat pyritised) are preserved, as well as impressions. Length of pinnae 80 mm. (incomplete); breadth of largest 31 mm.; breadth of narrowest 11 mm.

A careful comparison of the fossil with *Acrostichum aureum* L. and other ferns, in Kew Herbarium, led us to the conclusion that *A. Lanzaeanum* is closely allied to *A. aureum*, as earlier workers have stated, and that on barren fronds alone it cannot be distinguished from that living species. We therefore call it *Acrostichum* in preference to the less definite term *Acrostichites*. We have kept the old specific name "*Lanzaeanum*," for this may be regarded as a convenient term to denote closely comparable fossil forms of the genus based upon barren fronds alone. At first sight certain species of *Pteris* (§ Litobrachia) appear similar in form and nervation to the fossils and to *A. aureum*, but a closer examination reveals differences. So far as we were able to observe, in *Pteris* only the fertile fronds have entire margins: the sterile ones are finely dentate; the nervation also diverges from the midrib at a much wider angle than in *A. aureum* and *A. Lanzaeanum*, and follows a rectilinear, not a curvilinear, course outwards. In *Pteris* also, the nerves are sharply defined with long, clear, longitudinal striations and without the crumplings described in the fossil, and seen also in the living *Acrostichum*. Finally, in this section of *Pteris* the fronds are thinner and less coriaceous in texture.

REMARKS : The genus *Acrostichum* has frequently been recorded fossil in Europe at various horizons from the Eocene to the Miocene. It was first described by Visiani (1858), under the name *Fortisia Lanzaeana*, from the Eocene of Monte Promina. Later, de Saporta (1888a, 1890) recorded it from Manosque (*C. splendidum*) and from Aix (*C. minus* and *C. dilaceratum*).

Gardner and von Ettingshausen (1879) figured small pieces of *C. Lanzaeanum* (pl. ii, figs. 3 and 4) from the Lower Bagshot of Studland, Dorset, and a magnificent compound frond from the Middle Bagshot of Bournemouth (pl. i). Later, an Oligocene

pinnule was figured by Gardner (1886*a*) from the Bembridge beds of Gurnard Bay, and Professor Laurent (1899) described the same species from the Middle Oligocene of Célas.

In America the genus has a similar Tertiary range (Knowlton, 1919, pp. 58, 59). In Africa Professor Seward (1924) records it from the Lower Tertiary of South-Eastern Nigeria.

Our study of recent material of *A. aureum* in the Kew Herbarium and Gardens revealed the following facts of importance in connexion with fossil species. (1) The nervation may vary considerably in coarseness. (2) The size and shape of the pinnae may vary greatly, some being long and lanceolate, others short and oblong. (3) The form of the apex varies, and terminal pinnae may sometimes be lobed or bifid. (4) Although commonly stipitate, the pinnae are often sessile, especially near the tops of the fronds.

These differences are worthy of notice because certain fossil species have been differentiated from one another and from the living solely on such variable characters. Thus Gardner and Ettingshausen (1879, p. 27) regarded the more sessile pinnae as distinguishing *A. Lanzaeanum* from *A. aureum*, and Newberry's species *A. hesperium* was considered specifically distinct because it possessed lobed terminal pinnae (Newberry, 1898, pp. 6, 7). Such points as these show that, before describing a new fossil species, due consideration must be given to the possible range of variation among living representatives.

- V.17689 Figured Gardner (1886*a*, pl. iii, fig. 5), is a fairly large fragment of a pinnule.
- V.17490 Figured Pl. I, fig. 1, is part of a pinnule; both margins are missing, and the original breadth must greatly have exceeded that now seen.
- V.17491 Figured Pl. I, fig. 2, represents the lower surface of a pinnule. The counterpart shows part of the upper surface. Two smaller fragments are evidently from the same block.
- V.17492 Figured Pl. I, fig. 3, shows a fragment of a large pinnule (upper surface), the lower surface being represented on the counterpart.
- V.17672 Text-fig. 1a. A fragment with relatively fine nervation, and counterpart.
- V.17673 Text-fig. 1b, shows a fragment with very coarse nervation.
- V.17697 A fragmentary pinna with fine nervation, and its counterpart. In five pieces, which are apparently from the same stone as V.17492.
- V.17698-17705 Are all fragmentary pinnae, together with counterparts.
- V.17706-08 Have no counterparts.
- V.17709 Two fragments, with *Stratiotes* seeds on the same blocks.

In addition, numerous very small fragments have not been catalogued.

Family **SCHIZAEACEAE**Genus **LYGODIUM** Swartz1800 Schrader's *Jour. Bot.*, ii, p. 106.**Lygodium** sp. [?]1888 *Lygodium* sp., Gardner, *Rep. Brit. Ass.* (1887), p. 419.

Gardner (1888) includes *Lygodium* among plants determined during a visit with Saporta to the A'Court Smith Collection. Amongst the rock specimens which came to us six were assembled in a tray with an old faded label "*Lygodium*." All show mere scraps of fern badly preserved. One is labelled "*Lygodium*" on the actual stone; presumably therefore it is one of the specimens mentioned. As it is now almost obliterated it is impossible to know what it was like when Gardner saw it. The dichotomous and fern-like nervation can just be seen. Two other specimens are also too poorly preserved for comment.

V.17710 Labelled "*Lygodium*" on the stone.

V.17711 Two specimens too badly preserved for comment.

The remaining specimens are somewhat better preserved, but even so are too fragmentary for determination. Enough is visible to show that they belong to two genera; we therefore describe them separately as *Filices incertae sedis*, sp. 1 and sp. 2.

FILIX INCERTAE SEDIS, sp. 1

Plate I, fig. 6.

Pinnae asymmetric, main nerve apparently marginal, secondary nerves diverging from it, and running obliquely to the opposite margin, at which they end. Nervation dichotomous. Margin entire.

Epidermis of equiaxial cells with sinuous walls such as occur in many living ferns. Impressions with remains of carbonaceous matter. Length and breadth incomplete.

We do not think that these two specimens can possibly be *Lygodium*, or that they can have been mistaken for it. Possibly their association with the label "*Lygodium*" is accidental. Asymmetric pinnae of this type occur in *Adiantum*, *Didymochlaena*, etc., but the specimens are too imperfect for determination.

V.17493 Figured Pl. I, fig. 6, a pinna showing the main nerve and associated margin. The secondary nerves can be seen to arise from the main nerve.

V.17712 Shows the opposite margin at which the secondary nerves end.

FILIX INCERTAE SEDIS, sp. 2

Plate I, fig. 7.

Pinna rounded-oval, slightly lobed; midrib very broad and prominent, secondary nerves pinnate, parallel and close to one another, dichotomously branched. Length 16 mm.; breadth 8 mm.

Impression of the lower surface.

Nervation of this type occurs in *Lygodium*, also in other genera. The specimen is too fragmentary for determination.

V.17494 Figured Pl. I, fig. 7, the only specimen, is an impression of a fragment, or a small pinnule, with remains of carbonaceous matter.

FILIX INCERTAE SEDIS, sp. 3

Plate I, fig. 8.

Pinnule fragmentary, parallel-sided, with entire margin; nerves few, all prominent on the lower surface, and well defined although almost filiform; midrib well defined, slightly sinuous where the secondary nerves arise; secondary nerves given off at acute angles, usually bifurcating at from one-third to one-half the distance from midrib to margin, the upper branch generally bifurcating again, sometimes twice, the lower seldom doing so.

Length imperfect; breadth 5.5 mm.

One impression of the lower surface, on an ironstone nodule.

The fern bears a general resemblance to fossil species called *Lygodium*, but we have been unable to find any fossil in exact agreement with ours. The specimen is too fragmentary for determination.

V.17495 Figured Pl. I, fig. 8. Impression of the lower surface.

FILIX INCERTAE SEDIS, sp. 4

Plate I, fig. 9.

Pinnule fragmentary, parallel-sided, with cross-section of this form $\sim$, all nerves very prominent; secondary nerves few and rather widely spaced, diverging very gradually from the midrib and, after running subparallel with it for some distance, sweeping out to the margin at angles of about 70° . Most of the secondaries bifurcate once at about one-third or one-half the distance from midrib to margin. Margin of frond entire and straight. Length incomplete; breadth 2.25 mm.

One impression only.

Many ferns, e.g. species of *Osmunda*, *Marattia*, and *Scolopendrium* show nervation of this type, but we have seen no fructification, and cannot, therefore, determine such a fragmentary specimen.

V.17496 Figured Pl. I, fig. 9, is an impression of the lower surface.

FILIX INCERTAE SEDIS, sp. 5

Plate I, figs. 10, 11.

Pinnae shortly ligulate or oblong, somewhat cordate at the base, slightly stipitate. Nerves very numerous, flabellate, diverging both from the base and from the very inconspicuous midrib, which is only visible near the base; bifurcating frequently and obscurely at very acute angles. Epidermal cells of lamina oblong with the greatest length parallel to the nervation, and with walls slightly sinuous so as to give a somewhat irregular outline. Fertile fronds not seen. Length of complete pinnae 12.5 to 18 mm.; breadth, 9 to 11 mm.

Impressions, often with pyritised carbonaceous films.

The size, shape and nervation of the pinnules corresponds with *Aneimia oblongifolia* Swartz var. *lanosa* Baker. This fern shows the same fanning out of the nerves from the base and midrib, the pinnae are slightly stipitate, as in the fossil, and the epidermal structure is similar; but again, the fossil is too fragmentary for determination in the absence of reproductive organs.

- V.17497 Figured Pl. I, fig. 10, shows several fragments, one with perfect apex.
- V.17498 Figured Pl. I, fig. 11, shows several nearly perfect pinnae. The cordate bases are well seen. Remains also occur on the back of the stone.
- V.17713 Two fragments showing incomplete pinnules fairly well preserved.
- V.17714 Poor fragmentary pinnules of uncertain affinity, with counterpart.
- V.17715 Fragments of fern, of doubtful affinity, with counterparts.

FILIX INCERTAE SEDIS, sp. 6

Plate I, figs. 12, 13.

Fronds tri-pinnate, branches given off at angles ranging from 45° to 60°, pinnules at the ends of branches entire, those below slightly lobed, rounded at the apex, cuneate at the base. Nerves prominent on both surfaces, primary nerves thin, continued to the margin, slightly zig-zag; secondary nerves alternate, emerging from the midrib at acute angles, usually forking dichotomously. Length of largest fragment 40 mm.

Impressions only, with shreds of carbonaceous matter.

- V.17690 Figured Gardner (1886a, p. 403, pl. iii, fig. 6) as "Fern." Small fragment, now in a bad state of preservation.
- V.17499 Figured Pl. I, fig. 12. The largest fragment seen. It shows the delicate fragile habit.
- V.17500 Figured Pl. I, fig. 13. Three fragments, originally parts of the same frond, but the connexion between them now broken away. They show clear nervation.

V.17716 A tiny fragment, fairly well preserved.

V.17717 One fragment with counterpart. It shows the entire margin very clearly.

Order HYDROPTERIDEAE

Family SALVINIACEAE

Genus *AZOLLA* Lamarck

1783 Encycl. Méth., I, p. 343.

Azolla prisca n. sp.

Plate I, figs. 14-24 ; text-figs. 2, 3.

DIAGNOSIS : Macrosporangia with nine floats arranged in three groups of three ; macrospore tubercled and with fine filiform hairs ; massulae with non-septate glochidia.

HOLOTYPE : V.17502.

DESCRIPTION : Very numerous, isolated tufts of a small, profusely branching, heterosporous plant with the habit of *Azolla*.

Vegetative organs represented by impressions only (Pl. I, figs. 14, 17).

Leaves : Small, ovate or rounded, sometimes scattered, sometimes densely crowded, imbricate and concavo-convex (text-fig. 2) ; upper surface formed of large irregular hexagonal or polygonal cells with sinuous walls, and covered with short stiff hairs ; lower surface formed of inflated, bladder-like cells giving rise to coarse prominences.

Stems : Fairly broad, with elongate protuberances.



FIG. 2.—*Azolla prisca* n. sp. Camera lucida drawing showing vegetative habit. Magnified (see Pl. I, fig. 14). V.17002.

Roots : One specimen, V.17730, perhaps shows the impression of a root given off from a stem and lying across a leaf.

A number of barren branchlets from the Insect Limestone were figured by Gardner as flowering spikes of a grass (1886*b*, pl. iv, figs. 1-8).

Reproductive organs represented largely by actual organic entities.

Sporocarps : Of two kinds borne in pairs (or ? sometimes more, V.17502) at the bases of leaves, V.17678 and V.17719.

Female sporocarps : Acorn-shaped, pointed, seen only in external impressions, within which the elongate, apical cells of the indusium are sometimes preserved (text-fig. 3) at the narrow tip. One macrosporangium in each sporocarp (Pl. I, figs. 15, 16).

Macrosporangium : Comprising one large macrospore below with nine floats above, arranged in three sets of three, Pl. I, figs. 19, 20, 21. The sporangium-wall has perished except at the apex where it is represented by a small plate-like disc. Length 0.4-0.5 mm. approx.

Macrospore : Dark brown, with a perinium bearing filiform hairs and large protuberances, the latter especially marked at the

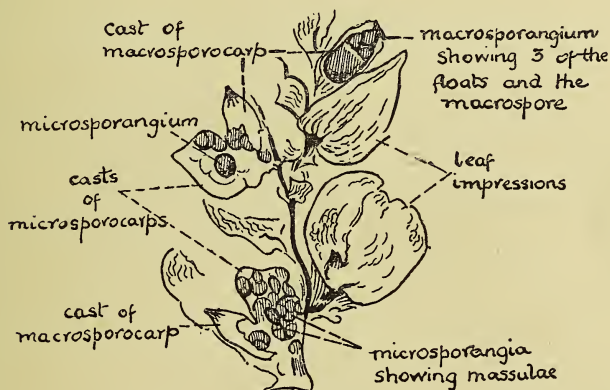


FIG. 3.—*Azolla prisca* n. sp. Diagrammatic drawing from photograph of fruiting branch of V.17678, $\times 18$.

base. A section through the macrospore shows a second inner coat. All the floats are embedded in a fibrous matrix; the six lower are easily detached, the three upper are covered by, and firmly fastened to, the remains of the sporangium. Normally, floats and macrospore remain united.

Microsporocarp : Large and globular, the external cast only is preserved, the wall having perished, but it shows the impressions of the numerous sporangia, which may themselves be preserved within the cavity (Pl. I, fig. 18, and text-fig. 3). Diameter 1.9 mm. approx.

Microsporangium : Globular, containing at least twelve agglomerated massulae. The massulae fall apart from one another on treatment with nitric acid, also in some cases as a result of fossilisation; they bear numerous, non-septate glochidia; they

are formed of small cells externally, and of large, loose-textured cells internally, among which the microspores are embedded (Pl. I, fig. 22).

Microspores: Minute, globular or tetrahedral, thin-walled, shining, showing tri-radiate markings (Pl. I, fig. 23).

AFFINITIES: The above characters leave no doubt as to the affinities of this plant. All are found in *Azolla*, distributed between the two sections into which the living genus is divided (Strasburger, 1873).

§ 1. *Euazolla* (2 spp. and 1 sub-sp.) is characterised by three floats to the macrospore and massulae with glochidia, which in *A. caroliniana* are septate and in *A. filiculoides* are not.

§ 2. *Rhizosperma* (2 spp.) is characterised by nine floats to the macrospore arranged in three sets of three, and massulae without glochidia.

A. filiculoides (§ 1) bears hairs and blunt protuberances on the perinium of the macrospore very like those of the fossil; *A. nilotica* (§ 2) bears very small, numerous protuberances not closely resembling those of the fossil.

By the occurrence of glochidia and by the tubercled, filament-bearing macrospore, the fossil is related to the *Euazollae*—more particularly to the species *A. filiculoides*. But by the nine floats to the macrospore it is related to the *Rhizospermae*. Probably, therefore, it represents an ancestral type in which features, now distributed, were combined. It is obviously more closely akin to each of the living groups than they are to each other, and either of these groups could have been derived from the fossil merely by suppression of parts—in the one case of the lower floats, in the other of the glochidia.

DISTRIBUTION: The present geographical distribution of *Azolla* is as follows—

§ 1. *Euazolla*. *A. filiculoides* Lam., California and S. America. *A. filiculoides* var. *rubra* R. Br., Australia, New Zealand, Tasmania. *A. caroliniana* Willd., N. America, Central America and Brazil.

§ 2. *Rhizosperma*. *A. pinnata* R. Br., Japan, East Indies, Ceylon, New Guinea, Australia, South and West Africa and Madagascar. *A. nilotica* Decaisne, White Nile.

It is interesting to note that, possibly after the lapse of ages, the genus has once again established itself in parts of Western Europe. *A. filiculoides*, introduced a few decades ago, now occurs profusely in the quiet waters of many parts of England, France, Germany and Italy.

The initial suggestion as to the position of this plant we owe to Mr. Leonard Boodle. We take this opportunity of expressing our thanks for the great help he has given us.

V.17502 Holotype, figured Pl. I, fig. 16. Three macrosporocarps (impressions) and two macrosporangia within the impressions.

On the other side of the stone a microsporocarp (Pl. I. fig. 18) full of microsporangia and massulae. Slide V.17502a was obtained from this specimen.

- V.17501 Figured Pl. I, fig. 15, shows the relation between the sporocarp and the foliage. The macrosporangium is very well preserved. On the back of the specimen there is a tuft of foliage, also one macrosporangium and a patch of massulae.
- V.17678 Text-fig. 3. A tuft of foliage bearing fructifications in the axils of the leaves—one solitary macrosporangium and two impressions of macrosporocarps each associated with a microsporocarp (impression) full of organic massulae.
- V.17001 Figured Pl. I, fig. 17. Tuft of foliage with a microsporocarp near the base full of massulae and sporeangia, with counterpart. Massulae from this specimen mounted on slide V.17001a and figured Pl. I, fig. 22.
- V.17002 Figured Pl. I, fig. 14 and text-fig. 2, represents a much-branched tuft of foliage.
- V.17505 A block full of scattered massulae and macrosporangia. A few microspores can be seen, and from this specimen the microspores in slide V.17505a were obtained. They are figured Pl. I, fig. 23.
- V.17504 A group consisting of several macrosporangia and three microsporangia. There are a few microspores isolated from the massulae preserved in a deep hollow between the macro- and micro-sporangia. From this block two of the macrosporangia (slide V.17504a) were obtained, and figured Pl. I, figs. 20, 21.
- V.17503 Several small vegetative tufts and a good achene of *Ranunculus heterostylus*. A macrosporangium on slide V.17503a was obtained from this rock and figured Pl. I, fig. 19.
- V.17679 Figured Gardner (1886b, pl. iv, fig. 1, 1a). Small tuft of foliage.
- V.17680 Figured Gardner (1886b, pl. iv, fig. 2, 2a). Tuft of foliage.
- V.17681 Figured Gardner (1886b, pl. iv, fig. 3). Small tuft of foliage and its counterpart.
- V.17682 Figured Gardner (1886b, pl. iv, fig. 4, 4a). Small tuft of foliage.
- V.17683 Figured Gardner (1886b, pl. iv, fig. 5, 5a, right hand side of figure only). Small tuft of foliage.
- V.17684 Figured Gardner (1886b, pl. iv, fig. 5, 5b, left hand side of figure only). Small tuft of foliage.
- V.17685 Figured Gardner (1886b, pl. iv, fig. 6, 6a). Foliage.
- V.17686 Figured Gardner (1886b, pl. iv, fig. 8, 8a). Branching tuft of foliage.
- V.17718 Foliage and microsporocarps full of massulae. A macrosporocarp is partially hidden by the microsporocarp, and there is also a cast of a second macrosporocarp. Massulae, stained with carbolfuchsin and mounted on slide V.17718a, were obtained from this specimen.
- V.17719 Shows three solitary macrosporocarps in the axils of leaves. The leaves show impressions of the protuberances which occur all over the lower surface in living species. On the other side of the stone there are several macrosporangia and scattered massulae.
- V.17720 Represents a small group of massulae.

- V.17721 A small tuft of foliage and a group of massulae and macrosporangia.
- V.17722 A small tuft of foliage ; on the reverse of the stone a few isolated massulae and macrosporangia.
- V.17723 A small group of massulae and macrosporangia.
- V.17724 A group of macrosporangia.
- V.17725 A tuft of foliage with an impression of a macrosporangium.
- V.17726 A tuft of foliage with a fragment of a macrosporangium. A number of microspores, liberated from the massulae, can be seen lying in a deep crack at the base of the tuft.
- V.17727 A tuft of foliage, and a badly preserved macrosporangium in the axil of a leaf.
- V.17728 Block and counterpart with small groups of massulae and macrosporocarps. A badly preserved *Cladiocarya* is on the back of one of the blocks.
- V.17729 Well-preserved massulae and macrosporangia scattered all over the surface of the stone and its counterpart. There are also impressions of *Engelhardtia* and *Hooleyia* nuts and an endocarp of *Potamogeton*.
- V.17730 A fragment of stem, bearing leaves, and possibly one root.
- V.17731 A branching tuft of foliage. The leaves show impressions of protuberances all over the lower surfaces. There are also impressions of two macrosporangia.
- V.17732 A branching tuft of foliage showing cell-structure on certain leaves.
- V.17733 A fragment of foliage with counterpart.
- V.17734-7 Four fragments of foliage with counterparts.
- V.17003-5 Vegetative fragments.
- V.17006 A fertile fragment ; also casts of *Sparganium*.
- Other specimens are catalogued under *Engelhardtia macroptera*, V.17984, and *Typha latissima*, V.17047, V.17800.

Order EQUISETALES

Genus EQUISETUM Linnaeus

1753 Spec. Pl., ed. i, p. 1061.

Equisetum lombardianum Sap.?

1886 *Equisetum lombardianum* de Saporta, *Bull. Soc. Géol. France*, (3), xiv, p. 422, pl. xx, figs. 2-5, pl. xxi.

Plate II, figs. 1-5.

DIAGNOSIS : Stems large, differing from those of the living *E. giganteum* Linn. in the more numerous and narrower ribs.

DESCRIPTION : Aerial stems large, cylindrical, hollow, jointed, with a sheath of scale leaves and a whorl of branches at the nodes ; exterior ribbed, surface finely striate. A series of peripheral lacunae, lying between the vascular strands in each internode, alternates with the series in adjacent internodes ; from twenty to about eighty lacunae were counted round the circumference.

Strands of thickening occur beneath the cuticle opposite, and intermediate to, the lacunae. At the nodes fibres from the stem-bundles pass out into the leaf-sheaths and branches; thin nodal plates divide the central cavity of the stem.

No complete internode is represented. Most of the specimens occur in a soft red rock.

The leaf-sheath is always imperfect, transversely rippled externally and divided into flattened ribs each of which represents a scale-leaf. The scale-leaves lie opposite to the lacunae in the same internode. Circumference of largest stem about 80 mm.; diameter of smallest 15 mm.; diameter of nodal plate 22-25 mm.

Branches rise at the bases of the leaf-sheaths between the leaves, usually opposite alternate stem-bundles; occasionally very few, perhaps two only, occurring in the whole circumference. External surface with strong transverse rugosities; sheaths formed of 6-8 leaves, about 0.6 mm. broad; the leaf tips are all broken. Diameter of branches 2 mm.; length of internodes 18-19 mm.

The plant is represented by casts and impressions of fragments only. The stems were broken and partially decayed prior to fossilisation, as is shown by their collapsed and flattened condition and by the fact that the inner vascular cylinder has usually perished. The inclusion of shells, fish-bones, and mud clearly demonstrates that they were hollow. Occasionally the epidermis has been shredded from the stems and preserved as an impression. The remains, usually isolated, never occur in thick masses.

The specimens include external impressions of the stems, casts of the central cavity, and internal casts of the cortex; the last-named being the most striking and abundant. They are longitudinally ribbed, the ribs, which are casts of the lacunae, alternating in adjacent nodes; each rib carries a shallow median depression due to the sub-cuticular thickening opposite the lacunae; sometimes the ribs are ornamented with a beautiful lace-like cell-structure, at other times they are finely striate. Between the ribs there are deep grooves which are impressions of the interlacunar tissue together with the strands of thickening alternating with the lacunae. At the nodes casts of the foramina for the sheath and branch bundles are clearly seen; those for the sheath fibres are small and opposite the lacunae in the internode above, those for the branch fibres are large, a little lower and alternate with the lacunae above.

A few counterparts show an external impression of a stem on the one counterpart (Pl. II, fig. 2), an internal cortical cast on the other, but nothing remains of the organic substance which originally lay between the two except a few carbonised fragments. The nodal plates are usually represented by isolated circular impressions with notched edges (Pl. II, fig. 5), but a few occur at the nodes in the position of growth.

AFFINITIES: A comparison of the fossil with living species

shows that it is comparable in size with *E. giganteum* Linn. only. One stem of this species in Kew Herbarium measures 35 mm. in diameter, so that it may be even larger than the fossil; but it has fewer and wider ribs, 76 being the greatest number we counted; while on other parts of the same plant, there were not more than 40. Variations in size of stem similar to those of the fossil occur in this species, and the length of the internodes is also very variable. The branches arise singly or in groups; when singly, they do not always occur between every pair of ribs. The sheath-teeth on the branches vary in number from 6-8. *E. giganteum* grows in the marshes of tropical America, from Mexico and Cuba to Buenos Ayres and Chili, ascending to 5000 ft. in New Granada.

Among recorded fossils *E. procerum* Heer. (1859, vol. iii, p. 158, pl. cxlvi, fig. 1) is larger—34 mm. broad—with fewer, wider ribs—about 30; *E. robustum* Newberry (1898, p. 15, pl. xvi, figs. 1, 2) is 17 mm. wide with only 24 ribs. *E. lombardianum* Saporta, from the Oligocene of Gard is the only fossil species closely comparable with the Bembridge *Equisetum*. Under this specific name Saporta unites stems from 20 to 40 mm. in diameter with ribs varying in number from 40 to 50. His estimate of the ribs is founded on the teeth, ours is on the lacunae or on the ribs themselves. But two at least of his figures (pl. xxi, figs. 1, 4) show respectively 31 and 30 alternations of ribs at the nodes on the one side of the stem figured. There must be, therefore, a total of about 60 ribs in the complete circumference. We think it probable that the Bembridge plant is a slightly more robust form of *E. lombardianum*. The two are of similar geological age. As, however, there are no complete sheath teeth preserved at Bembridge, so that their form is unknown, the ascription to *E. lombardianum* is doubtful.

We were not able to make comparison with *E. sulcatum* Dunal, another large form from the Eocene of Aude with which Saporta (1886, p. 424) compared his species. He distinguished *E. lombardianum* by the fewer, shorter internodes, narrower and more finely pointed teeth. Dunal (1848) evidently considered that the apparent teeth in *E. sulcatum* were formed by the union of several single ones. Such a union sometimes occurs in *E. giganteum*, in which as many as five teeth may be united. Possibly, therefore, the differences between *E. lombardianum* and *E. sulcatum* may be more apparent than real.

- V.17506 Figured Pl. II, fig. 1. An internal cast of the cortex of a large flattened stem. Also two counterparts showing impressions of the external surface. At the node, on the internal cast, branch- and leaf-traces can be clearly seen.
- V.17507 Figured Pl. II, figs. 2, 3. Internal cortical cast of a small stem, and its counterpart showing the external impression of the same stem. Since the internal cast was figured, an adjacent fragment has been found and affixed to it. One

other small fragment represents another portion of the counterpart.

- V.17508 Figured Pl. II, fig. 4. A node with branches, also a counterpart.
- V.17509 Figured Pl. II, fig. 5. A nodal diaphragm and its counterpart.
- V.17738-40 Three incomplete nodal plates.
- V.17741 The same, with counterpart.
- V.17045 A node, and its counterpart, with the nodal plate *in situ*.
- V.17742 One side of an internal cortical cast, and a counterpart showing a portion of the external surface (impression) of the same stem.
- V.17743 A block with two external impressions of stems, and corresponding counterparts. Each counterpart shows an almost perfect internal cast of the cortex, and one has part of a nodal plate *in situ*.
- V.17744 The base of a leaf-sheath, at the internode, with about 12 teeth on one side. Also a counterpart.
- V.17745 A piece of epidermis detached from a stem.
- V.17746 An internal cast of the cortex with nodal diaphragm approximately *in situ*.
- V.17747 Internal cast of pith cavity.
- V.17748 Small stem and a counterpart.
- V.17749 Much decayed stems, one showing external surface, with counterparts.
- V.17750-1 Two fragments of stem.

GYMNOSPERMAE

Order CONIFERALES

Family ARAUCARINEAE

Genus ARAUCARITES Presl

1838 In Sternberg, Fl. d. Vorwelt, ii, p. 203.

In investigating the Bembridge specimens of *Araucarites* we have had the invaluable collaboration of Dr. Rudolf Florin, of Stockholm. Unfortunately, owing to delay in the arrival of material for comparison from some of the continental localities, Dr. Florin has been unable to complete his investigations in time for this catalogue. We can therefore only give his tentative opinion, which is, that more than one species is represented among the fossils referred to the genus *Araucarites*, but that the delimitations of the species, and their distribution, must remain uncertain until the full investigation has been completed. We give our own description of the morphological character of the twigs, because we had more material for comparison than it was possible to send to Dr. Florin. This is followed by Dr. Florin's description of the cuticles, and discussion of the genus and species; but the whole

account, as it stands, has been submitted to Dr. Florin for his approval.

Our share in the diagnosis of the new species was so slight as to be negligible, and the whole credit is due to Dr. Florin. We have great pleasure, therefore, in assigning the authorship of the name to him.

Araucarites gurnardi Florin n. sp.

Plate II, figs. 6-19.

- 1884 *Araucaria Goepperti*? Sternberg: Gardner, *Eocene Flora*, ii, p. 59, pl. xiii, fig. 7.
 1886 *Doliosirobus Sternbergii* (Goeppert): Gardner, *op. cit.*, p. 93, pls. xxii, xxiii.
 1888 *Doliosirobus Sternbergii* (Goeppert): Gardner, *Rep. Brit. Ass.* (1887), pp. 419, 423, pl. iii, figs. 32-34.

DIAGNOSIS: *Araucarites* twigs characterised by shorter, relatively broader, less falcate leaves than those of *A. Sternbergii* Goeppert (1850, p. 236, pl. xlv, fig. 1), and Ettingshausen (1853, p. 36, pls. vii, viii). Leaves more or less appressed, or occasionally spreading.

HOLOTYPE: V.17513.

DESCRIPTION: *Twigs* branching at angles of 28° - 45° , branchlets slender and clothed with rather long imbricate leaves. Gardner states (1886, p. 93) that the mean angle of branching is 45° ; but with the exception of the specimen figured pl. xxii, fig. 1 (now in the Sedgwick Museum) and one other, we have seen none making so wide an angle. In the specimen figured pl. xxii, fig. 2, Gardner shows the left-hand branchlet either distorted or broken just above the angle of emergence, probably the latter. The average angle is about 30° to 35° .

Leaves spirally arranged, quadrilateral in section with median ridges on both sides, straight or falcate, narrowed to a slender, sharp point, usually more or less appressed, but occasionally spreading. At the base of the yearly twigs, the leaves tend to be shorter, and closer. This close arrangement was somewhat over-emphasised by Gardner in some of his figures (1886, pl. xxii, figs. 4, 11), and the falcate character under-emphasised. Pl. II, fig. 8, in the present work, is a photograph of two fragments illustrated separately by Gardner in his figures 4 and 11 just mentioned. The upper part corresponds with fig. 4; the lower with fig. 11. We found the two specimens were parts of the same twig, and joined them: the crack across can be seen rather more than half-way up the figure. Old stems show impressions of leaf-scars, cf. Gardner, 1886, pl. xxii, fig. 12, illustrating a specimen now in the Sedgwick Museum. Greatest length of leaf 13 mm., average length from 7 to 9 mm.

Cuticle: DR. FLORIN writes: "The stomata occur in two

bands on each side of the leaf; these are broadest at the base, becoming gradually narrower towards the apex. Fig. 10 (cuticle from V.17511) shows three stomatal bands in the middle part of a leaf, the one on the left belonging to the upper (ventral) side, and the other two to the under (dorsal) side. Fig. 11 (from the same specimen) shows the two stomatal bands on the upper side near the leaf apex. Fig. 12 shows a portion of a stomatal band on the upper side of a leaf (specimen V.15208, figured Gardner (1888, pl. iii, fig. 34).

"The stomatal bands of the *upper* side of the leaf are relatively narrow. They are broadest at the base, where four to five stomata abreast can be seen. At the extreme apex the band gets narrower and consists finally of a single row. The distribution of stomata is somewhat irregular, straight rows occurring only for short distances. The orientation of stomatal axes varies within wide limits; there are not only vertically and horizontally oriented stomata, but also many more or less oblique in direction; the horizontally oriented ones seem, however, to be in the majority. On the upper side of the leaf the stomata are placed near one another, and there are only a few ordinary epidermal cells between them.

"The stomatal bands of the *lower* side of the leaf are broader, and the stomata themselves lie more sparsely distributed, than on the upper side. At the base there are eight or nine stomata abreast; in the middle and upper part the bands get gradually narrower and reach almost as far towards the apex as the corresponding bands on the upper side. Towards the leaf-bases, the stomata are arranged in vertical rows which are more distinct than in the upper part of the leaf, where they are more irregularly distributed. The intervals between neighbouring stomata in both vertical and horizontal directions are wider on the lower side of the leaf than on the upper. On the lower side there are more of the vertically oriented stomata than on the upper.

"The stomata are distinctly separated from each other and never seem to possess any subsidiary cells in common. The latter are narrow and placed end to end in a ring, and so form a wide pore, above the guard cells, which constitutes the 'äussere Atemhöhle.' The number of subsidiary cells varies between four and six. In the lower part of fig. 13 there is a stoma with four subsidiary cells. Fig. 15 shows one with five such cells, and fig. 16 one with six. Sometimes two subsidiary cells are placed opposite each other in the direction of the slit between the guard-cells; in such cases polar and lateral subsidiary cells can be distinguished (fig. 13). In many instances, however, there is no such definite relation between guard-cells and subsidiary cells. The cuticle of the subsidiary cells is slightly thickened towards the 'äussere Atemhöhle,' which is wide and not very deep. At the bottom of the pore are the two guard-cells, the outer walls of which are

cuticularised only to a very slight degree ; the slit between them is generally distinct.

"The epidermal cells in the stomatal bands vary in form. Usually they have their long axes parallel to the long axis of the leaf, but between two adjacent stomata in the same vertical row there are often one or two cells intercalated with their long axes horizontal. Between the stomatal bands and at the margins of the leaf, where no stomata occur, the epidermal cells are more uniform and mostly rectangular. They are vertically oriented and arranged in vertical rows. Many epidermal cells show small, flattened and irregularly shaped papillae (?) on the outer surface (figs. 13, 16). The cell-walls are always straight, not wavy."

DISCUSSION : "Coniferous remains such as these have usually been described under the name *Araucarites Sternbergii* Goepf.

"The genus *Araucarites* was instituted by Presl (in Sternberg, 1838, p. 203), for *Araucaria*-like coniferous remains, cones as well as sterile branches. He mentioned two species : (1) *Araucarites Goepperti* Presl, founded on a detached and imperfectly preserved cone from the older Tertiary strata at Håring, in Tyrol ; and (2) *Araucarites peregrinus* (Lindl. & Hutt.) Presl, founded on sterile branches from the Liassic beds at Lyme Regis, Dorset. The first-mentioned specimen seems to be of very little value, and there is no sufficient reason to refer it to *Araucarites*. I venture to propose the designation *Conites Goepperti* (Presl). The second species is usually referred to the more artificial genus *Pagiophyllum* Heer and need not be discussed here.

"Although the genus *Araucarites* was thus founded on material insufficient to prove, at that time, a close relationship to the recent *Araucaria*, it seems suitable to retain it for coniferous remains, fertile as well as sterile, which show closer affinity with the recent genus *Araucaria* than with any other known genus. This is in accordance with the view held by Prof. Seward (1919, p. 268).

"Goeppert described later, under the name *Araucarites Sternbergii*, sterile twigs from the locality in Tyrol which yielded the above-mentioned cone. A sterile twig was figured by him in 1850 (pl. xlv, fig. 1), in his monograph on the fossil conifers, and he regarded it as possibly belonging to the same species as the cone in question. As the correctness of this opinion could not be actually proved, he preferred to institute the new specific name *Sternbergii* for the sterile material.

"It can be seen from the illustrations in the works of Goeppert (*loc. cit.*), Ettingshausen (1853, pls. vii, viii), and Unger (1851, pl. xxv), that at least the greater part of the *Araucarites*-twigs collected at Håring belong to the same specific type as those specimens found at Bournemouth and figured by Gardner (1884, pl. xi, fig. 1, pl. xii) under the name *Araucaria Goepperti* Sternb. In accordance with the opinion of Prof. Seward (1919, p. 268), it seems desirable to retain the species-name *Sternbergii* for this

type of leafy twig, characterised by relatively long, narrow, somewhat spreading and falcate leaves.

"Unger referred to the same species a number of specimens from Sotzka (1851, p. 157, pl. xxiv). These specimens seem possibly to represent another type of *Araucarites*-twig characterised by shorter, relatively broader, less falcate and usually more or less appressed leaves. Some of the specimens from the Eocene at Messel, near Darmstadt, much resemble the material from Sotzka, but differ markedly from the Häring type of foliage, which seems to be altogether lacking at Messel. The specimens from Gurnard Bay belong apparently to the species represented at Sotzka.

"Thus it seems necessary to institute a new specific name for the Gurnard Bay specimens.

"It is probable that all the specimens of *Araucarites*-type from Häring, Sotzka, Messel, Bournemouth, Chiavon, Gurnard Bay and Alais belong to the same natural genus, or, possibly, to two nearly related genera. The cuticular structure of the leaves is remarkably uniform. All the specimens hitherto investigated have the cuticle of most of the ordinary epidermal cells furnished with peculiar small papillate protuberances (?) on the outer side, considered to be pits by Dr. Bandulska (1923, p. 249). I have not yet been able to make out with certainty the nature of these structures. They are not met with, so far as I know, in recent Araucarians.

"The arrangement and structure of the stomata agrees very well, on the whole, with *Araucaria*. As these are the most important diagnostic characters of Conifer cuticles, the name *Araucarites* seems fully justified. However, more fertile material is needed before its exact relationship to *Araucaria* can be satisfactorily determined.

"Some authors have wrongly referred similar material to *Sequoia*, but this genus is apparently not represented in the material under investigation. The specimens from Messel determined by Engelhardt (1922) as *Athrotaxis* (?) *subulata* Gardn., *Cryptomeria Sternbergii* Goepp., *Doliotrobus Sternbergii* Goepp., and *Sequoia Sternbergii* Ett., all belong to the genus *Araucarites*."

In accordance with Dr. Florin's opinion, stated above, a new name—*Araucarites gurnardi*—is given to the Gurnard species.

The plant occurs throughout the Bembridge Marl. It is usually preserved as hollow casts in clay-ironstone nodules, which may, or may not, enclose carbonaceous remains. Occasionally, however, well-preserved remains are embedded in a soft white matrix, and these yield the best cuticle.

V.17513 Holotype, figured Pl. II, fig. 9. Twigs showing habit and branching.

V.17510 Figured Pl. II, fig. 6, twig.

- V.17511 Figured Pl. II, fig. 7. Carbonaceous twig embedded in soft white marl. From this specimen the cuticle figured Pl. II, figs. 10, 11, 13-16, was obtained (slides *a* & *b*).
- V.17512 Figured Pl. II, fig. 8. Specimen of twig (two pieces joined by us). The upper portion figured by Gardner (1886), pl. xxii, fig. 4; the lower pl. xxii, fig. 11.
- V.15207 Twig figured by Gardner (1888, pl. iii, fig. 33). Near base of Bembridge Marl; Hamstead, Isle of Wight. *Purchased of J. S. Gardner*, 1892.
- V.15208 Twig, embedded in soft white matrix, figured by Gardner (1888, pl. iii, fig. 34). From this specimen the cuticle figured Pl. II, fig. 12, was obtained. Near base of Bembridge Marl; Hamstead, Isle of Wight. *Purchased of J. S. Gardner*, 1892.
- V.17691 Branching twig figured by Gardner (1886, pl. xxii, fig. 2). The upper part of the specimen, found by us and joined, was not figured by Gardner.
- V.17693 Twig figured by Gardner (1886, pl. xxii, fig. 5). The part with twig to the right and cone scale is now broken from the specimen and lost.
- V.17694 Twig with spreading foliage figured by Gardner (1886, pl. xxii, fig. 7).
- V.17695 Twig figured by Gardner (1886, pl. xxii, fig. 9).
- V.17752 Small fragment with spreading foliage.
- V.17753 Good fragment showing branching.
- V.17754-56 Three fragments showing older twigs with leaf scars.
- V.17757-59 Three good specimens of twigs.
- V.17760-73 Fourteen specimens all with counterparts.
- V.17774-78 Good specimens showing branching.
- V.17779 A number of fragments all from one block which probably yielded the type specimen.
- V.17780-87 A number of specimens in a hard white or grey matrix, probably *Araucarites gurnardi*.
- V.17788 Small fragment of twig, with unidentified object (impression) on same block.
- V.17019 Doubtful fragment of *Araucarites*, with counterpart.

Genus DOLIOSTROBUS Marion

1884 *Compt. Rend. Acad. Sci.*, xcix, p. 821.

Doliosrobis sp. (*Araucarites gurnardi* ?)

Plate II, figs. 17, 18.

DESCRIPTION : Cone-scales broadly oval, truncate at the base, terminating at the apex in a conspicuous, rather short, parallel-sided or conical mucro. Limb of scale closely and coarsely ribbed on the lower part of the ventral side, smooth on the upper part (fig. 17); dorsal side irregularly ribbed below, smooth above (fig. 18). Length 11 mm.; breadth 11 mm.

Several impressions in clay ironstone, associated with, but not in organic continuity with, foliage of *Araucarites gurnardi*.

DISCUSSION: The cone-scales described resemble those of *Agathis*. They agree in general form and character with the scales figured by Marion as *Doliostrobus Sternbergii* (1888, pl. ii, figs. 15-17), but they differ in being less attenuated at the base, shorter, and with a more parallel-sided mucro. It is possible, but not probable, that the Bembridge scales are in every case broken at the base. On the evidence as it stands at present, they cannot be referred to Marion's species.

Further, we agree with Dr. Florin that, until evidence of organic continuity is forthcoming, the cone-scales cannot be referred to *Araucarites gurnardi*, but must be placed provisionally in Marion's genus *Doliostrobus*. Nevertheless, their occurrence both in the Isle of Wight and at Alais, in association with *Araucarites* foliage, suggests that they may, eventually, have to be referred to that genus.

V.17514 Figured Pl. II, fig. 17. Impression of upper surface of cone-scale. Twig of *Araucarites gurnardi* on same block.

V.17515 Figured Pl. II, fig. 18. Impression of lower surface of cone-scale. Twig of *A. gurnardi* on same block.

V.17789 Cone scale and twig of *A. gurnardi* on same block.

V.17790 Base of cone-scale (large and elongate). Fragments of twig of *A. gurnardi* on same block.

Semen Incertae Sedis

Plate II, fig. 19.

Seed asymmetric with large puckered, transverse wing on one side only. Wing diaphanous. Length of seed 3 mm.; breadth 1 mm.; breadth including wing 7 mm. One impression, in clay-ironstone, with twigs of *Araucarites gurnardi*.

The form of seed and wing is in close agreement with *Agathis*. The seeds figured by Marion (1888, pl. ii, fig. 18) differ from the Bembridge specimen in the more terminal, less asymmetric and oblique wing. It should be noted that the seeds do not occur in organic connection with the associated scales and twigs, either in the Alais or the Bembridge material.

V.17516 Impression of seed. Twig of *Araucarites gurnardi* on same block.

Family ABIETINEAE

Genus PINUS Linnaeus

1753 Spec. Pl., ed. 1, p. 1000.

**Pinus Dixoni* (Bowerbank)

1850 *Pinites Dixoni* Bowerbank. In Dixon's Geol. Sussex, ed. 1, p. 84, pl. ix, fig. 3.

1878 *Pinites Dixoni* Bowerbank: Carruthers in Dixon's Geol. Sussex, ed. 2, p. 162.

- 1884 *Pinus Dixoni* (Bowerbank): Gardner, Eocene Flora, p. 67, pl. xiii, fig. 4.

A cone obtained by A'Court Smith from Gurnard Bay was figured by Gardner under the name *Pinus Dixoni* Bowerbank. The type of the species came from Bracklesham. It was described as "elongated, subcylindrical, swollen towards the base; five inches long, one and a half broad on the upper half. Scales thickened at the apex, with a rhomboidal obtusely spinous apophysis" (Carruthers in Dixon, 1878, p. 162).

Gardner states of the Bembridge cone that "the apophyses are in every case abraded except towards the tip of the cone, where they are almost concealed by pyrites. When visible, however, they are seen to be quite similar to those . . . described [in the type]. What remains of the cone is six inches long, nearly cylindrical, somewhat pointed at the apex, obtusely rounded at the base, and composed of fourteen whorls of about ten scales. . . . The nearest existing species seem to be *P. laricio*, *P. pyrenaica* and *P. halepensis*, pines belonging to the Mediterranean region."

The specimen has not been traced; probably it has completely decayed, judging from the description of its pyritised condition. The generic determination was probably correct.

**Pinus vectensis* Gardner

- 1888 *Pinus vectensis* Gardner, *Rep. Brit. Ass.* (1887), pp. 419, 423, pl. iii, fig. 31.

A second cone figured by Gardner in 1888 was probably washed out of the Bembridge marls. He states that "It measures 32 mm. in length and 22 mm. in breadth, and is composed of some 40 scales. The scale heads are hexagonal and rather prominent, but partially obscured by encrusting pyrites. No internal structure is visible. It is the smallest pine cone yet recorded from our tertiaries, and appears to be allied to the section of *P. mugho*."

Probably this specimen also has now decayed. It is curious that, in his revised list of Bembridge plants, Gardner (in Bristow, etc., 1889, p. 183) omits this species, although he mentions *P. Dixoni*. The generic determination is probably correct, judging from the figure.

Pinus sp. 1 (Seed)

Plate II, fig. 20.

Wing asymmetric, large but narrow, nearly parallel-sided below, rounded obliquely above, with fine, longitudinal, wavy, parallel striations formed by oblong cells. The cells become larger, markedly irregular and more contorted towards the oblique side. Surface undulating longitudinally but not transversely crumpled.

At the base of the wing there is a small circular gap which was occupied by an abortive seed. The concavity seen to the left of this gap is very characteristic of abortive seeds from the basal scales of *Pinus*. Length of wing 13 mm.; breadth 4.5 mm. Impression only.

V.17517 Figured Pl. II, fig. 20. An impression of an abortive seed, and its counterpart.

Pinus sp. 2

Plate II, figs. 21, 22.

A cluster of about seven needles which evidently belong to a species of *Pinus*. Their bases are broken, so that it is impossible to tell whether or not they formed a single tuft. Each needle has a wide median band of stomata. Length incomplete; breadth 1.1 mm. Impressions, with fragments of organic substance only.

V.17016 Figured Pl. II, figs. 21, 22; and counterpart.

Genus **PITYOSPERMUM** Nathorst

1897 *K. Svensk. Vet. Hand.*, xxx, p. 62.

Pityospermum ambiguum n. sp.

Plate II, fig. 23.

DIAGNOSIS: Seed winged at the apex, large, obovate, symmetrical; both seed and wing with longitudinal striae not converging at the base; seed without contorted cells; wing with contorted cells near one margin only, strongly puckered transversely.

HOLOTYPE: V.17518.

DESCRIPTION: Seed (including wing) large, broad, obovate, nearly symmetrical; seed itself rounded-triangular, broader than long, symmetrical, delimited from the wing by a groove; wing broad, symmetrical, gradually widening above, broadest near the apex, conspicuously crumpled transversely. Both seed and wing striate longitudinally with oblong cells which become shorter and more lenticular and contorted at the left-hand edge of the wing. There are no contorted cells over the seed as in *Pinus*, and the striations do not converge at the base, but run parallel in a longitudinal direction until they meet the margins of the seed. From this arrangement it is clear that the wing slightly enveloped the seed on the naked side. Length, including wing, 11.5 mm.; breadth of seed 4.5 mm.; breadth of wing 7.5 mm.

DISCUSSION: The general form of seed and wing, the character and arrangement of the cells over the wing (aligned in rows near one margin, contorted near the other), the manner in which the wing enveloped the seed, all place the fossil in the Abietineae in which two seeds are developed on each cone-scale

The species is remarkable for (1) the symmetrical shape both of seed and wing, (2) the transverse crumpling of the wing, (3) the regular alignment of the cells, without contortions either at the junction of seed and wing or over the seed itself.

The fossil is represented by counterparts (impressions) which fit so closely that there can hardly have been room between them for a ripe seed. We think that the seed was covered completely by the wing on one face, but that on ripening it dropped free, as constantly happens in *Picea excelsa*. It was evidently not a species of *Pinus*, in which genus the wing only forms a rim to the ripe seed, so that when the seed is detached it leaves an oval hole at the base. The symmetrical form of the fossil is extremely rare among living genera; it occurs in *Picea schrenkiana*, but the seeds of that species are very small and the wing is not transversely crumpled. On the whole, the greatest resemblance is to *Picea*, but we do not feel confident that the fossil should be referred to that genus, on account of its great size.

V.17518 Figured Pl. II, fig. 23, is an impression of the winged seed, and its counterpart.

V.17792 (Counterparts) and **V.17793** may perhaps belong to the same species, but as they are either abortive or incomplete they cannot be determined with certainty.

Family TAXODINEAE

Genus SEQUOIA Endlicher

1847 Synops. Conif., p. 197.

Sequoia Couttsiae Heer [?]

1883 *Sequoia Couttsiae* Heer: Gardner, Eocene Flora, p. 36, pl. vi, fig. 9.

1886 *Athrotaxis Couttsiae* (Heer): Gardner, *op. cit.*, p. 91, pl. xxii, figs. 10, pl. xxvii, figs. 4, 4a.

Several small coniferous fragments were labelled *Sequoia Couttsiae*, and some of these were figured by Gardner. The leaves are smaller and broader, and the habit is more slender than is usual in specimens of *Araucarites*, but the tips of twigs only are represented, which may account for the differences. Apart from these fragments, no organs referable to *Sequoia* have been found. The ascription to the genus may be correct, but we consider the fragments too small, and the evidence too imperfect, to be of much value. All are impressions.

Gardner's erroneous reference of *S. Couttsiae* to the genus *Athrotaxis* has been fully discussed elsewhere (C. & E. M. Reid, 1910a, pp. 170, 171, pl. xv., figs. 23-41; Chandler, 1922), and the evidence need not be repeated here.

- V.17696 Figured by Gardner (1886, pl. xxii, fig. 10). The figure of the right hand twig shows more than the specimen warrants, and omits a falcate leaf at the base which is somewhat reminiscent of *Araucarites*. The specimen is preserved in Insect Limestone.
- V.17692 Figured by Gardner (1886, pl. xxvii, figs. 4, 4a). The figure gives quite an adequate representation of the specimen. Also counterpart.
- V.15124 Figured by Gardner (1883, pl. vi, fig. 9). A rather poor figure of a very slender twig. Indeterminable.
- V.17794 Several specimens preserved in white rock. These were found in a tray with an old label "*Sequoia Couttsiae*." Most are fragments of conifer, but too indefinite for determination.

Family CUPRESSINEAE

Genus CUPRESSUS Linnaeus

1753 Spec. Pl., ed. 1, p. 1002.

Cupressus sp.

Plate III, figs. 1, 2.

DESCRIPTION : Cone small, nearly globular (distorted obliquely) composed of twelve, or possibly fourteen, scales of which four are large and sub-basal, four are median, and two (or possibly four) are apical. There is also evidence of at least one abortive basal scale. Scales markedly peltate on slender stalks, ribbed along the stalk and inner surface, with a well-defined band of honeycomb cells round the inner edge. Escutcheons rugose, with a broadly triangular, prominent umbo directed upwards. Number of seeds unknown. Diameter of cone about 10 mm.; breadth of large basal scales 6.4 mm.

The cone is represented by two parts : (1) an outer shell showing the external impression of the escutcheons only a few of which are complete ; (2) an inner core, which has now broken away from the shell, representing the infilling between the scales. The core is, therefore, a cast of the stalks and inner surfaces of the peltate scales (see Pl. III, figs. 1, 2) ; it is complete except at the extreme base, and shows all but one of the scales.

The escutcheons of the basal scales, two of which are represented, are contiguous ; those of the median scales are widely gaping, so that evidently the cone was ripe and had shed its seeds.

AFFINITIES : At first we thought that this cone might belong to *Sequoia*, but after taking casts of the escutcheons, which, taken together with the core, showed the form, number, and relationship of the scales, a strong resemblance to the cones of *Cupressus* became evident. At that time, however, only three median scales were visible, whereas, in *Cupressus*, there are four. The position of the fourth scale was occupied by a shred of *Typha*, but when this was

chiselled away the missing scale was exposed, somewhat distorted from its true position, and partly covered by one of the others. We subsequently replaced the fragment thus removed so that the fourth scale is now again hidden, but its position is shown by a gap in the *Typha* fragment (Pl. III, fig. 2).

The cone is small, rather larger than those of *C. Lawsoniana*. The scales, too, are more peltate in this species, fewer in number, and more closely packed. In *C. macrocarpa*, otherwise unlike it, we have frequently counted as many as fourteen scales, although most species produce only ten or twelve.

Many fossils—both fruits and twigs—from the Jurassic onwards, have been referred to *Cupressus* or *Chamaecyparites*. The only ones that need be considered in connexion with the Bembridge specimen are a few of those based on cones. *Cupressus Pritchardi* (Goeppert) Gardner (1884, pp. 82–84, pl. xvi, figs. 8, 9, pl. xviii, fig. 1, pl. xix) has fewer scales. *Chamaecyparites Hardtii* Endlicher, first described from foliage only, and later from cones also (Ettingshausen, 1853, p. 35, pl. vi, figs. 1–21), has more than ten scales, judging from the figures, but is larger than the Bembridge fossil and has smooth escutcheons with a central umbo.

As we cannot refer the fossil with confidence to either of these species, and as its specific characters are not clear owing to the mode of preservation, we have given no specific name.

V.17519 The only specimen; it consists of four fragments, one representing the central core (internal casts of the cone-scales) figured Pl. III, figs. 1, 2, and three representing portions of the external impression of the cone.

Genus **LIBOCEDRUS** Endlicher

1847 Synops. Conif., p. 42.

? **Libocedrus** sp.

Plate III, fig. 3.

DESCRIPTION: Twig flattened, with two whorls of leaves, and in the axils of the upper whorl the bases of a pair of symmetrically placed branches. Each whorl is oval-oblong below, expanded above, and is composed of two pairs of leaves of equal length. The lateral leaves are conduplicate, embracing and differing from the flat appressed facial leaves. Conduplicate leaves somewhat sigmoidally curved and oblong or sub-oblong below, narrowed at the base, with patent cuspidate tips; they do not meet at the base so that the facial leaves are visible between them throughout their length. Facial leaves parallel-sided below from two-thirds to three-fifths of their length, expanding above into a patent triangular apex. Wedge-shaped portions of the lowest leaves of the branches

are visible between the lateral and facial leaves of the main twig for one-third the length of the whorl on one side, and nearly half the length on the other. Length of one whorl 4 mm.; breadth in the lower part 1.7 mm.; length of second whorl 4.5 mm.; breadth 1.7 mm.; visible breadth of lower part of facial leaf 0.5 mm.; visible breadth of lateral leaves (half of each can be seen) 0.6 mm.

The plant is represented by a single impression.

AFFINITIES: In order to identify this specimen we examined all the genera of § Cupresseae.

Cupressus and *Fitzroya* are too unlike for comparison. *Callitris* and *Actinostrobus* are ruled out by the arrangement of their leaves in whorls of three, so that when seen from one side only they present alternations of two and three leaves to a whorl; the only exception is a species with long pointed leaves quite unlike those of the fossil.

In *Thuya* and *Thuyopsis* the lateral leaves do not meet at the base of the whorl. But these genera differ from the fossil in their relatively shorter broader whorls, more narrowed below, in which neither facial nor lateral leaves are parallel-sided. The facials are cuneate below and the laterals ovoid.

In *Chamaecyparis* the same differences occur, and, further, the facial leaf of the main axis is not clearly delimited by overlap from the first branch-leaf, but is distinguishable by a slight notch and furrow only.

There remain the two monotypic genera *Fokienia* and *Tetraclinis* (*Callitris* Vent. pars) and the genus *Libocedrus*. In the latter, only two species, *L. decurrens* (American) and *L. macrolepis* (Chinese) are sufficiently like the fossil to require comparison. All three genera present strong similarities; in all, there are flat branches with large leaves in whorls of four arranged as in the fossil, and although in *Libocedrus* the branching is commonly alternate, yet opposite branches do occur in the species mentioned. The whorls of the fossil most nearly resemble *Libocedrus* in profile. Those of *Fokienia* tend to be more cuneate; those of *Tetraclinis* more elongate and strictly oblong. Again, the form of the individual leaves is like *Libocedrus*. The lateral leaves of *Fokienia* are more oval and broader below and the facials appear cuneate because they are more overlapped by the laterals than in the fossil. All the leaves of *Tetraclinis* are more parallel-sided, especially at the base, and are scarcely cuspidate above. It must be noted, however, that these characters are somewhat variable in the living species, and there are only two nodes of the fossil: much too small a fragment to furnish any definite conclusions.

The one foliage character which is stable and of generic value, so far as we can judge, is the degree to which the main facial leaf overlaps the basal branch-leaf. In the fossil, as stated, the branch-leaf is visible for a distance varying from one-third to one-half the

length of the main facial ; in *Fokienia* it is visible for the whole length of the main facial ; in *Tetraclinis* it can only be seen from one-sixth to one-quarter of the length, and in *Libocedrus* from one-quarter to one-half the length. From these and the preceding observations, it appears that the fossil agrees most closely with *Libocedrus* (*L. macrolepis* and *L. decurrens*), and that there is a less marked resemblance to *Tetraclinis*. On the evidence afforded by comparison with living material alone, we should, therefore, be tempted to refer the Bembridge plant to *Libocedrus*, but a consideration of fossil evidence from other sources ought perhaps to modify this opinion.

There are only two fossil species at all comparable—*Callitris Brongniarti* Endlicher and *C. Heeri* Saporta—and of the two the Bembridge fossil more resembles *C. Heeri*. Fruits, seeds, and foliage of both species are known. The fruits and seeds point to a near relationship to *Tetraclinis articulata* (= *Callitris quadrivalvis* Vent.) whereas the leaves more resemble those of *Libocedrus decurrens*. Since fruits and seeds are a surer guide than leaves in discriminating between these related genera, we consider the ascription of *C. Brongniarti* and *C. Heeri* to *Tetraclinis* to be correct. It appears that the leaves of the Bembridge fossil are yet more nearly related than those of *C. Heeri* to *Libocedrus decurrens*, but the fruits and seeds are absent, and without these organs the evidence is inconclusive. The plant may be a true *Libocedrus* or it may be a yet closer link than *C. Heeri* between *Libocedrus* and *Tetraclinis*, just as *Fokienia* constitutes a link between *Libocedrus* and *Cupressus*.

V.17520 Figured Pl. III, fig. 3, is the only specimen.

ANGIOSPERMAE

Class MONOCOTYLEDONES

Family TYPHACEAE

Genus TYPHA Linnaeus

1753 Spec. Pl., ed. 1, p. 971.

Typha latissima Al. Braun

Plate III, figs. 4-11.

1851 *Typha latissima* Al. Braun in Stizenberger, Verstein., p. 75.

1855 *Typha latissima* Al. Braun : Heer, Flora Tert. Helvet., i, p. 98, pls. xliii, xlv.

DIAGNOSIS : Leaves distinguished from those of other species by their greater breadth and thickness. Fruit with long stalk

and style, and with more numerous and more slender elongate blotches than in any living species.

DESCRIPTION : *Leaves :* Ligulate, thick, sheathing at the base, each leaf completely embracing the one inside, alternate or nearly so. Free blade plano-convex, usually represented by external impressions combined with internal casts. External surface finely and uniformly striate. Natural transverse and longitudinal sections show a single layer of large longitudinal lacunae arranged in a row, each divided by transverse parenchymatous partitions. These lacunae give rise to a characteristic structure of parallel ribs divided transversely into oblong segments seen in internal casts of the leaves (Pl. III, figs. 4, 5). Width of largest leaf 20 mm.; length always incomplete; greatest thickness at base 6 mm.

Fruits : One-seeded, fusiform, narrowed at one end into a long stalk, at the other into a style. Stalk filiform, style linear, flat, broadening above into a ligulate stigma. Pericarp formed of tapering cells with conspicuous, elongate, black blotches which are found also on the stigma. Fruit represented by casts but with the organic blotches still adhering. Length of fruit with style and stalk (possibly incomplete) 5 mm.; length without style and stalk 1.25 to 2 mm.; breadth 0.7 mm.

Seeds : Actual seeds, detached or lying within the fruit; pendulous, anatropous, albuminous, elongate-ovoid, truncate at the micropyle, pointed at the chalaza. The micropyle and chalaza are often marked by brown staining of the testa and by the radiation of the cells from those points. Micropyle large, closed by a flat disc with central mucro; raphe lateral, filiform. Testa of two layers: (1) an outer light brown layer formed of hexagonal, transversely elongate cells, the angled ends of which alternate so as to produce zig-zag longitudinal ridges with a slight spiral twist; (2) a delicate hyaline inner layer, closely investing the endosperm, formed of long slender cells tapering at both ends. The two layers are sometimes fused and at other times separate. Albumen represented by a cream-coloured granular substance. Length of seed 0.9-1.1 mm.; breadth 0.4 mm.

Leaves occur in great profusion; fruits and seeds are frequent.

AFFINITIES : The evidence that these organs belong to *Typha* is complete. The fruits and seeds both show all the characters of the genus. Comparison of the fruits with those of *T. latifolia*, *T. elephantina*, *T. angustifolia*, and *T. javanica* shows that they are least like those of *T. latifolia*, which are larger and unblotched. The fossil fruits more resemble those of the other three species, but the blotches are more numerous and slender than in any of them. The seeds of *Typha* are anatropous, the raphe appearing externally as a delicate white thread. The leaves most resemble *T. elephantina* Roxb., a species living in the Mediterranean region and East Indies; those of other species are too slender and thin. Leaf

fragments were figured by Gardner who thought that they probably belonged to *Typha* (1886*b*, pl. iv, figs. 15, 17).

Comparison with other fossil species shows that the leaves correspond with *T. latissima* Al. Br., as figured by Heer (1855, pp. 98, 99, pls. xliii, xlv). Schimper noted in 1870 (vol. ii, p. 470) that fossil fruits of *Typha* were unknown.

The occurrence in the Bembridge beds of one species of undoubted *Typha* represented by fruits and seeds, and of one species (equally well characterised) represented by leaves, makes it certain that the two belong to the same plant. We have therefore associated the remains under the leaf name *Typha latissima* Al. Br.

- V.17521 A group of leaves, figured Pl. III, fig. 4. It includes external impressions and internal casts; the latter are divided into oblong areas—the casts of the lacunae.
- V.17522 A single leaf, figured Pl. III, fig. 5, in part an external impression and in part an internal cast; it shows the form of the leaf in transverse section.
- V.17523 Leaf-fragments, external impressions and internal cast. A fragment of the latter figured Pl. III, fig. 6, to show the lace-like transverse partitions which divide the longitudinal lacunae.
- V.17524 Figured Pl. III, fig. 7, represents part of a stem with three sheathing leaf-bases.
- V.17525 Figured Pl. III, fig. 8. The impression of a fruit with long style and stalk and with dark blotches (organic) adhering to the surface.
- V.17526 Figured Pl. III, fig. 9. Represents the impression of a fruit with an actual seed lying within it.
- V.17527 Figured Pl. III, fig. 10. Three groups of seeds lying in the matrix.
- V.17528 Figured Pl. III, fig. 11. An isolated seed.
- V.17795 Impressions of leaf-fragments (counterparts).
- V.17796 Block with impressions of leaf-fragments and possibly of a *Typha* rhizome.
- V.17802-04 Fragmentary impressions or casts of leaves.
- V.17797 A fruit (impression) and counterpart.
- V.17798 A fruit; impression with organic remains.
- V.17799 A fruit (impression).
- V.17800 Three fruits or fragments of fruits, two represented on the counterpart. On the back of the rock specimen there are two imperfect seeds of *Typha*. A few *Azolla* fruits are scattered over the surface.
- V.17801 Seeds; several detached from the stone and mounted. One shows the remains of the endosperm.
- V.17805 *Typha* seed or fruit? Badly preserved.
- V.17806 *Typha* seed? Impression.
- V.17807 *Typha* seeds? Lying in the matrix.
- V.17010 Block with numerous leaf fragments; also part of small anterior lobe of *Engelhardtia* bract.
- V.17020, V.17040-1 Leaf fragments.
- V.17047 Leaf fragments, and vegetative tufts of *Azolla*.

Numerous other specimens have not been catalogued.

Family SPARGANIACEAE

Genus SPARGANIUM Linnaeus

1753 Spec. Pl., ed. 1, p. 971.

Sparganium multiloculare n. sp.

Plate III, figs. 12-18.

DIAGNOSIS: Fruit large, fusiform. Endocarp large, woody, two to five-loculed, irregularly and sharply grooved and angled.

HOLOTYPE: V.17529.

DESCRIPTION: *Fruit*: A drupe, large, fusiform, ribbed below, smooth and finely striate above. Represented only by casts (Pl. III, fig. 12). Length of fruit, 9.5-10.5 mm.; breadth, 4.5-5 mm.

Endocarp: Large, woody, irregularly obovoid, two to five-loculed; irregularly, conspicuously, and sharply grooved and angled at the sides. Locules arranged radially, but sometimes unequally developed, or displaced upwards or downwards. Carpels usually distinct and obconical at the base, pierced at the apex by the large stylar canal which is closed at the inner end by a thin, flat, circular cap with central mucro; internal cavity of locule ovoid. Represented by external casts, internal casts (Pl. III, figs. 12, 13) and by the actual organ itself (Pl. III, figs. 14-16). Length of endocarp, 4 mm.; breadth 3.5 mm.; length of locule 3 mm.; breadth 1.1 mm.

Seed: Ovoid, anatropous, pendulous, raphe on the side away from the axis, crescentic in section; testa fused with the endocarp except at the large, circular, basal chalaza, thin, almost hyaline, formed of small square cells, which radiate from the chalaza at the base, but elsewhere form short transverse striations. The dimensions are those of the locule (given above).

AFFINITIES: The specimens are very numerous and the different modes of preservation make the anatomy very clear. The evidence for the inclusion of this species in the genus *Sparganium* is therefore complete. The whole anatomy supports this ascription; the living species differ only in the smaller number of carpels (one or two), but a consideration of other fossil evidence accounts for this difference.

From the Lower Pliocene of Pont-de-Gail one of the authors figured *Sparganium ovale* (Reid, 1920b, p. 58, pl. iii, figs. 1, 2), allied to the living *S. ramosum*. The frequent occurrence of two locules was noted, although one-loculed fruits predominated. From the Danish Pleistocene amber-pine beds (so named because they contain remanié amber) Dr. Hartz described a species with two to four locules (1909, p. 126, pl. v, figs. 14-16), which he referred to *S. ramosum*. The living *Sparganium* never has more than two locules, and normally most species have one; but two American

species, *S. Greenei* Morong and *S. eurycarpum* Engelm., have two habitually. The fossil evidence summarised shows that the number of locules tended to be greater in past ages than it is to-day, and the diluvial Danish fossils point to the reduction having occurred comparatively recently. We may therefore conclude that with the passage of time a reduction in the number of carpels of a syncarpous fruit has taken place (see p. 30).

Leaves : In certain clay-ironstone nodules leaves of a reed-like nature occur abundantly. They may perhaps belong to *S. multiloculare*. They are flat, parallel-sided, with a series of from twelve to twenty conspicuous parallel nerves between, which about five finer nerves can sometimes be seen. These longitudinal nerves are sometimes crossed by fine transverse partitions formed of irregular parenchymatous cells. Length unknown; breadth 15-22 mm.; distance between the conspicuous nerves 1·1 mm.

These leaves are much compressed and their general condition is very poor. They are represented by impressions only, except for a film of carbonaceous matter over some of the nerves. We have interpreted them from the leaves of living species—*S. ramosum*, *S. Greenei*, and *S. eurycarpum*—which afford a satisfactory explanation, but *S. Greenei* alone has leaves of comparable size (17·5 mm. broad). Externally, the living species show strong nerves alternating with from three to five finer nerves. Internally, a series of longitudinal lacunae is seen, the walls of which are parenchymatous tissue strengthened by strands of fibres. Where the lacuna-walls meet the epidermis, strong fibres occur, and smaller intermediate fibres run close to the epidermis. These alternations give rise to the coarse and fine nerves. The lacunae are segmented internally by partitions which correspond with those seen in the fossil. The condition of preservation determines whether the longitudinal fibres or the transverse partitions are most clearly seen in the Bembridge material.

Among fossil leaves those of *S. valdense* Heer most resemble *S. multiloculare*; but the fruits of *S. valdense* are much smaller and quite unlike (Heer, 1855, i, p. 100, pl. xlv, fig. 7), so that if we are right in associating the fruits and leaves of the Bembridge beds, any ascription to that species is precluded. We have therefore given a new name, taking the fruits as types of the species.

Both fruits and leaves occur in the clay-ironstone, but the former are rare. In the Insect Limestone leaves have not been recognised up to the present time, but fruits are very abundant.

V.17529 Holotype, figured Pl. III, fig. 12. The impression of a fruit and the internal cast of a four-loculed endocarp within it.

V.17530 Figured Pl. III, fig. 13. A five-loculed endocarp viewed from above, represented by an external impression, internal casts of the locules, and carbonaceous remains of the endocarp wall. The micropylar plugs are beautifully preserved, adhering to the casts of the locules, at the apex.

- V.17531 Figured Pl. III, figs. 14, 15. A five-loculed endocarp and its impression.
- V.17532 Figured Pl. III, fig. 16. An endocarp, lying in the matrix, broken longitudinally; it shows two large locules with apical apertures and a third smaller one somewhat displaced by the pressure of the other two. Each locule is lined by the closely adherent testa of the seed except over the clearly-marked basal chalaza and the basal part of the raphe, where it is broken away.
- V.17533 Figured Pl. III, fig. 17. An endocarp split longitudinally through two locules. One half shows the hilum and apical end of a raphe lying closely adjacent to the external side of the large micropyle. A micropylar plug could originally be seen closing the gaping aperture of one seed and locule.
- V.17808 Endocarp with counter-part, showing the external impression and enclosing the actual endocarp itself.
- V.17809 Poor external impression, and good internal cast, of four-loculed endocarp. A corona of ironstaining in the surrounding matrix gives a misleading appearance of a perianth.
- V.17810 External impression and internal cast of fruit and endocarp, with counterpart. The matrix stained all round the fossil.
- V.17811 A poor impression of an endocarp surrounded by a corona of staining; with counterpart.
- V.17812 Impression of a fruit with counterpart.
- V.17813 Actual endocarp and external impression of the same.
- V.17814 Imperfect endocarp.
- V.17815 Fragments of endocarps.
- V.17816-23 Eight impressions with counterparts.
- V.17824-35 Twelve external impressions of fruits.
- V.17836-49 Fourteen specimens showing external impressions and internal casts of endocarps.
- V.17850 Two blocks, showing fragmentary endocarps and internal casts of endocarps. An external cast of *Cladiocarya* also occurs on each block.
- V.5566, V.6352 Fragments of casts of endocarps.
- V.17026 Cast of endocarp.
- V.17027 Cast and actual endocarp.
- V.17043 Endocarp.
- V.17534 Figured Pl. III, fig. 18. Impression of leaf fragments, probably of *Sparganium multiloculare*. Poorly preserved.
- V.17851-52 Slabs of the same leaves, also badly preserved.
See also V.17955 catalogued under *Palmophyllum*, p. 80.

Family **POTAMOGETONACEAE**Genus **POTAMOGETON** Linnaeus

1753 Spec. Pl., ed. 1, p. 126.

Potamogeton pygmaeus Chandler

Plate III, figs 20-22.

1925 *Potamogeton pygmaeus* Chandler, Upper Eoc. Flora, p. 13, pl. i, fig. 3.

DIAGNOSIS: Fruits very small, laterally compressed, sub-ovate, with long spines on the dorsal margin and with a very stout spine at the middle of the ventral margin. Style terminal on the ventral margin. Endocarp thin-walled.

DESCRIPTION: *Fruit:* Sub-ovate, somewhat laterally compressed, curved about a central condyle which corresponds with an external depression on each of the lateral faces, spiny on the dorsal margin and with a large stout spine at the middle of the ventral margin (Pl. III, fig. 21). Style terminal on the ventral margin, broad at the base and gradually tapering, recurved at the tip. Fruit represented by external impressions. Length including style 1.25-1.5 mm.; breadth 0.75 mm.; length of longest spine 1 mm.

Endocarp: Thin-walled; form similar to that of the fruit. Germination valve (hitherto described by us as the keel) large and broad, extending from base to apex but not reaching the style, crested medianly and with about six or seven long slender spines which occasionally fork. External surface showing quadrilateral cells aligned in the direction of curvature (Pl. III, fig. 22); internal surface smooth and shining, striate in the direction of curvature. Endocarp represented by actual organic entities often lying within the impressions of the fruits, and by internal casts. Length 0.75 mm.; breadth 0.6 mm.

Seed: Sickle-shaped, with the chalaza at the end of the upper limb, and the micropyle at the end of the lower. Testa hyaline, shining, finely striate in the direction of curvature. Seed represented by the actual testa.

AFFINITIES: The Bembridge fruits correspond in all respects with *P. pygmaeus* Chandler, from the Upper Eocene of Hordle. The only difference is the better preservation of the long spines in the fine Bembridge Insect Limestone. In the coarse sandy matrix of Hordle the bases alone remain, the slender spines themselves having broken away.

V.17535 Figured Pl. III, fig. 19. Group of fruits (casts) showing mode of occurrence in Insect Limestone; also a few casts of *Limnocarpus spinosus*.

- V.17536 Figured Pl. III, fig. 20. Fruit with well-developed spines (impression).
 V.17537 Figured Pl. III, fig. 21. Fruit with well-developed style and spines including median ventral spine; impression with counterpart.
 V.17538 Figured Pl. III, fig. 22. Endocarp lying in matrix showing external cell-structure. With counterpart.
 V.17853 Specimen showing seed.
 V.17854 Specimen showing spines.
 V.17855 Group showing good endocarps with spines, several other fragments, and external impressions of *Limnocarpus spinosus*. With counterpart.
 V.17856-57 Two specimens with counterparts.
 V.17858-62 Five specimens showing external casts.
 V.17863-65 Three specimens showing internal casts.
 V.17866-71 Six specimens with organic remains of endocarp or testa.
 V.17024 Endocarp with spines; cast of unripe *Clematis* on same block.
 V.17025 Cast of seed.
 V.17054 Endocarp showing spines.

Potamogeton sp. (*pygmaeus*?)

Plate III, figs. 23, 24.

Leaf small, thin, oval or ligulate, sessile, base sometimes auricled. Midrib extending to the apex, with one or more pairs of longitudinal, sub-parallel nerves arising from the base, and curving round to unite with the midrib just below the apex; a fine nerve runs close to, and parallel with, each margin, and joins the adjacent longitudinal nerve some distance from the apex. The nerves do not draw together at the base, so that they must have passed separately (as spaced) into the stem; hence the leaf must have been attached by almost its whole breadth. Two specimens show fragments of the stem still adhering at the base; these fragments are composed of large air-cells through which, in one instance, the nerves can be seen to pass. Transverse nerves with a slight inclination upwards connect the parallel series, while the surface of the lamina shows a network of large quadrilateral cells (see Pl. III, fig. 23, at the left near the base). Length 7-12 mm.; breadth 3-4.2 mm. Impressions of both upper and lower surfaces.

The thin blade and large cells indicate that the remains belong to a water-plant, and the nervation and structure are seen in certain species of *Potamogeton*. It is therefore possible that these leaves, and the fruits of *P. pygmaeus*, belong to the same species.

- V.17539 Figured Pl. III, fig. 23. A ligulate leaf (impression).
 V.17540 Figured Pl. III, fig. 24. An oval leaf (impression) with slightly auricled base.
 V.17872 A ligulate leaf (impression) and counterpart.
 V.17873 Fragment of ligulate leaf.
 V.17874 Two doubtful specimens of leaf.
 V.17964 Impressions of ligulate leaves.

Potamogeton ? sp. 2

Plate IV, fig. 9.

1886 *Eriocaulon* sp., Gardner, *Proc. Geol. Assoc.*, pl. iv, fig. 16.

Stem with close-set, long, flat, ligulate leaves given off approximately at right angles ; leaf bases overlapping the adjacent younger leaves. Leaves finely striate with a few stronger striae fairly evenly spaced (about four or five), evidently thin and flaccid, as they are bent and twisted. Length of fragment of stem 24 mm. ; length of longest leaf (none is perfect) 28 mm. ; breadth 2·3 mm.

The overlap of the leaves is shown in the impressions by a series of imbricate laminae along the stem, each of which passes into a leaf. .

This plant was figured by Gardner as *Eriocaulon*, but the habit is not in agreement with such an ascription ; the leaves of *Eriocaulon* form a basal tuft and are stiff, not flaccid.

Thin, flaccid leaves with similar nervation and cell structure and a somewhat similar habit are found in species of *Potamogeton*, but usually, in this genus, the tufts are shorter, with fewer leaves ; they occur at the nodes only and are separated by leafless internodes. In *Najas*, especially *Najas major*, comparable tufts are seen, but the leaves are more or less finely spiny at the margin, and are without parallel nerves.

V.17548. Figured Pl. IV, fig. 9. The only specimen, with counterpart.

Genus **LIMNOCARPUS** Reid emend.1898 *Journ. Linn. Soc. Bot.*, xxxiii, p. 464.

DIAGNOSIS : Fruit a drupelet, carpels two, stalked, adhering by the ventral margin, style long ; endocarp hard, rugose, spiny or pitted, with a large germination valve (keel) ; seed curved round an excentric process on the locule wall, lower limb much larger than the upper ; testa hyaline.

Aquatic herbs related to *Potamogeton* and *Ruppia*.

GENOTYPE : *Carpolithes headonensis* Gardner. Lower Headon of Hordle.

DISCUSSION : The Bembridge material has given us the opportunity of examining a large number of specimens of *Limnocarpus* preserved rather differently from those in the Lower Headon beds. The fruit frequently retains its original form, uncompressed, with an internal cast preserved in calcite. Moreover, a second species belonging to the genus has been found. In view of the fresh evidence, we have been obliged to make one or two alterations or additions to Reid's generic description.

(1) We have deleted "fructus succulentus ?" because we have found no evidence of a succulent fruit, although in specimens

preserved as are the Bembridge fossils, it would be possible for some trace to have remained. The evidence adduced by Reid as possibly indicating a fleshy mesocarp is (a) the convergent stalks which cannot have connected the two carpels unless they were already connected in some other way, (b) the tubercled rugose surface.

The position of the stalks as figured by Reid (1898, p. 465, text-fig.), is, however, somewhat abnormal even in the Headon material. A large number of double specimens, since obtained, show that more commonly the stalks are contiguous and united (Chandler, 1925, p. 13, pl. i, fig. 4). Further, tubercled or spiny endocarps are found in living genera of Potamogetonaceae in which the fruits are not succulent; thus *Potamogeton trichoides*, *P. acutifolius* and *P. cristatus* have either jagged crests or long spines on the germination valve, and *Ruppia* sp. from Lake Ellesmere, Canterbury, New Zealand, is spiny all over its surface.

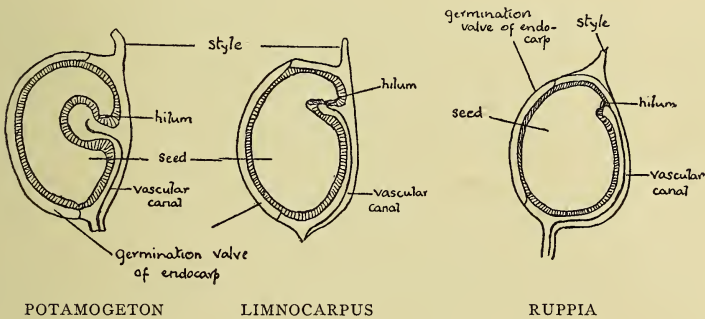


FIG. 4.—The internal anatomy of the genera *Potamogeton*, *Limnocarpus* and *Ruppia*. Endocarps in longitudinal section, showing the seeds (diagrammatic).

(2) In our opinion the chief and most reliable distinction between the three genera, *Potamogeton*, *Limnocarpus*, and *Ruppia*, in the absence of all but the fruiting organs, lies in the internal anatomy of the fruit and its relation to the seed (see text-fig. 4).

In *Potamogeton* there is a large, sub-circular median process projecting inwards from each face of the carpel; these processes uniting, form an internal condyle around which the seed is curled in a sickle-shaped curve, the two limbs being of much the same order of magnitude.

In *Limnocarpus* the processes are narrow, oblique and excentric, forming an internal ridge about one-third the length from the apex, near the ventral margin. About this narrow ridge the seed is crooked sharply upon itself. The two limbs of the curve are very unequal, the upper being quite small, and the lower large and swollen.

In *Ruppia*, although there are two depressions on the outside

as in the preceding genera, there are no corresponding processes on the inside; the seed, therefore, appears neither curved nor hooked, but only very slightly emarginate at the corresponding point.

In view of these differences, we have described the internal process as "excentric," in the diagnosis of *Limnocarpus*, and have added the fact that the lower limb of the curved seed is larger than the upper.

The anatomy suggests that *Limnocarpus* possesses characters intermediate between *Potamogeton* and *Ruppia*, but whether it be ancestral to both, or an extinct branch of the family Potamogetonaceae, there is at present no evidence to show.

Limnocarpus headonensis (Gardner)

Plate IV, figs. 1-3.

1888 *Carpolithes headonensis* Gardner, *Rep. Brit. Assoc.* (1887), pp. 420, 423, pl. iii, fig. 30.

1898 *Limnocarpus headonensis* (Gardner): Reid, *Journ. Linn. Soc. Bot.*, xxxiii, p. 464, text-fig. p. 465.

1925 *Limnocarpus headonensis* (Gardner): Chandler, *Upper Eoc. Flora*, p. 13, pl. i, figs. 4 *a-c*; text-fig. 3.

DIAGNOSIS: *Carpel* large, sub-ovoid, rugose or pitted, with long style on the ventral margin. Germination valve with three strong ridges, one median and two lateral.

DESCRIPTION: *Carpel*: Sub-ovoid, curved round a narrow oblique excentric process one-third length from the apex; style long, patent, apical on the ventral margin, vascular canal on the ventral wall, placenta close to the internal process. Surface rugose, pitted, with an especially large, deep pit on each face corresponding to the internal process. Germination valve ovate, broad, not reaching the style, with three strong ridges (fig. 3). Length about 2 mm.; breadth 1.5 mm.; thickness 1.1 mm. External impressions, internal casts and actual carpels.

Seed: Sharply curved, lower limb much larger than the upper; chalazal at the end of the upper limb, micropyle near the base of the lower; testa thin, hyaline, shining, striate in the direction of curvature. Represented by the testa, usually much shrivelled.

REMARKS: This species occurs fairly frequently in the Bembridge marls, although it is much less abundant than in the Lower Headon from which it was first described. No pairs of fruits have been found.

The endocarps represented by organic entities usually occur in soft white marl, but they are badly preserved and much shrunken and cracked. They can be isolated from the matrix by careful washing. In a hard white rock, beautiful calcite casts of the locule are fairly common, the calcite in solution having apparently filtered

in through the vascular canal which is also often filled with calcite. There are, in addition, numerous impressions and casts in clay-ironstone nodules.

It is highly probable that the fruits called *Cyperites Forbesii* Heer (1862, p. 373, pl. xviii, figs. 20, 21) and Gardner (1888, p. 422, pl. iii, fig. 16) are flattened, badly preserved specimens of *Limnocarpus* (see Reid, 1898, p. 466), probably of *L. headonensis*. The descriptions and figures are too poor to be of value.

V.17541 Figured Pl. IV, fig. 1. Internal cast of endocarp.

V.17542 Figured Pl. IV, fig. 2. Endocarp.

V.17543 Figured Pl. IV, fig. 3. Endocarp lying in matrix showing germination valve.

V.17875-81 Blocks containing numerous specimens; many with good calcite casts.

V.17882-85 Four specimens in clay-ironstone; internal casts and impressions of carpels.

V.17886-87 Two specimens in clay-ironstone. Some casts, and some actual endocarps.

V.17893-94 Endocarps released from soft marly matrix.

V.17888 Counterparts, *L. headonensis*?

V.17889-92 Several specimens of *Limnocarpus*, probably *L. headonensis* much flattened (cf. *Cyperites Forbesii* Heer).

***Limnocarpus spinosus* n. sp.**

Plate IV, figs. 4-8.

DIAGNOSIS: Carpels smaller and more inflated than those of *L. headonensis*, ovoid or sub-globose; style long and conical; surface with scattered spines; germination valve with three low, rounded, ridges; median ridge with tubercles.

HOLOTYPE: V.17544.

DESCRIPTION: Carpel smaller and more inflated than the last, ovoid or sub-globose, curved round an excentric, internal process as in *L. headonensis*. Style long and conical, about one-fifth the length of the carpel exclusive of the pedicel; pedicel thin, fairly long. Carpel wall thick and hard, ornamented with many fairly long, scattered spines; sometimes there are two especially conspicuous spines about the middle of the ventral margin. External surface with a deep pit on each face corresponding to the internal process. Germination valve broad, not extending to the style, with low marginal ridges and a rounded median ridge which bears a few large tubercles (possibly spine-bases). Length (exclusive of style and stalk) 1.2 to 1.3 mm.; breadth 1.1 mm.; thickness 1 mm. Carpels represented by organic entities and by external impressions and internal casts.

Seed: As in *L. headonensis* only smaller. The species is abundant in the Insect Limestone.

V.17544 Holotype, figured Pl. IV, fig. 4. Half an endocarp.

- V.17545 Figured Pl. IV, fig. 5. Group showing external impressions of endocarps, with counterpart.
 V.17546 Figured Pl. IV, fig. 6. Fruit showing two spines on the ventral margin ; broken so as to show the internal cast.
 V.17547 Figured Pl. IV, figs. 7, 8. Endocarp.
 V.17895 Specimen with stalk showing interior of carpel.
 V.17896-907 Twelve specimens variously preserved.
 V.17908-19 Twelve blocks showing external impressions and internal casts, also actual endocarps and seeds.

Family NAJADACEAE

Genus NAJAS Linnaeus

1753 Spec. Pl., ed. 1, p. 1015.

Najas oligocenica n. sp.

Plate IV, fig. 10.

DIAGNOSIS : Fruit small. Seed lanceolate-oval ; testa thin, with about twenty rows of oblong cells which are about twice as long as they are broad, and have beaded walls.

HOLOTYPE : V.17549.

DESCRIPTION : *Fruit* : One-seeded, elongate-oval ; pericarp thin, light brown, composed of cells elongate longitudinally.

Seed : Lanceolate-oval, truncate at the base, rounded at the apex. Testa thin, ornamented with about twenty rows of oblong cells ; the longest is about twice as long as broad, but they become smaller and more quadrate towards the base. The walls of these cells are irregularly thickened so that they present a beaded appearance in surface view, while in profile they appear minutely tubercled. Length about 1·5 mm. ; breadth (flattened) 0·5 mm.

The plant is represented by two actual seeds with almost contiguous bases, and with slightly divergent apices. Each apex is enveloped completely by the actual pericarp, but towards the base this structure is broken away, remaining only on the outside of one seed, and between the two. Both fruits have been considerably flattened by pressure so that the sections of pericarp and seed in each form concentric ellipses, the ellipse of the pericarp being narrower in proportion than that of the seed. This flattening, coupled with the further fact that the interspace between the ellipses is filled with matrix, shows that at the time of deposition the pericarp must have occupied the whole of this interspace, otherwise its thin walls would have collapsed upon the seed and there would have been no interspace. Probably, therefore, the inner cells of the pericarp were once turgid as in the living *Najas marina* and *N. graminea*.

AFFINITIES : The seed is comparable in size with small living species of the genus. In *N. Kingii* the fruits vary from 0·75 to

2 mm., and in several species they are about 1 mm. Apart from its size, the fossil seems most to resemble *N. gracillima* in general form and cell-structure. This species grows in the eastern United States of America.

Heer describes and figures two species with fruits from Oeningen, but both are much larger than the Bembridge fossil could have been when perfect, and the seeds, in both cases, are unknown.

V.17549 Holotype, figured Pl. IV, fig. 10. Shows two seeds as described.

Family **HYDROCHARITACEAE**

Genus **OTTELIA** Persoon

1805 Synops. Pl., I, p. 400.

Ottelia britannica n. sp.

Plate IV, figs. 11, 12.

DIAGNOSIS: Spathe small with several (? twelve) broad, thin, undulating, lateral wings, striate transversely. Fruit with delicate, longitudinally striate, perianth segments projecting above the spathe.

HOLOTYPE: V.17007.

DESCRIPTION: *Spathe:* Small, thin, delicate, ovoid, oblique at the apex, tapering gradually into the long, thick, soft stalk, with several (? twelve) broad, thin, undulating lateral wings arising at the base or slightly decurrent on the stem and extending to the apex, and with shorter wings interpolated in the upper part. The wings are wrinkled and striate transversely, the striations being particularly conspicuous at the margins; the cells are small and polygonal. Length of spathe, 3 to 5.25 mm.; breadth (including wings), 2.75 mm.; breadth of lateral wings, 0.6 to 0.8 mm.

Fruit: Carpels hidden by the spathe, above which project the thin, delicate, petaloid, longitudinally striated perianth segments, some of which are much broader than others; their number is uncertain. Length of fruit including stalk 17.5 mm.; length of perianth segments 3 to 4 mm.; breadth of wide perianth segments 1.1 to 1.5 mm.; breadth of narrow segments 0.4 mm.

The plant is represented by impressions, and appears to have been of a soft delicate habit.

The conspicuous longitudinal grooves on the spathe, seen in the illustrations, are narrow clefts which are the imprints of the lateral wings. These can be seen in profile, as wide flanges on either side of the spathe, as well as in section, in Pl. IV, fig. 12.

Pl. IV, fig. 11, represents two fruits lying side by side. The oblique apex of the spathe is best seen in the left-hand specimen (in which there are no perianth wings preserved). The highest point of the spathe is on the right, and against the oblique line which

defines it the lateral wings die out in succession. The same obliquity can be observed in the right-hand specimen and in Pl. IV, fig. 12, where the edge of the spathe is much higher on the right than on the left. It is difficult to estimate the normal number of perianth wings. The right-hand specimen, Pl. IV, fig. 11, has five, with a gap for a possible sixth to the right. Three broad ones are segregated at one side, and two narrow ones at the other. The difference in breadth may be due to the occurrence of petaloid and sepaloid perianth wings, but in *Ottelia* the sepals alone are persistent ; it is therefore more probably due to the presence of two fruits within the spathe—one better developed than the other. We found two fruits in a spathe of *Ottelia alismoides* Pers., in Kew Herbarium. The thin spathe, with undulating lateral wings, and the perianth projecting above it, seen in the fossil, are in complete agreement with *Ottelia*.

AFFINITIES : At first we looked for this plant among winged inferior fruits such as *Amomum* (Zingiberaceae) and *Trichopus* (Dioscoreaceae) in which the perianth segments persist as wings. But several facts militated against such a determination (*a*) the large number of lateral wings in the fossil, with shorter wings interpolated between them ; (*b*) the longitudinal striation on the perianth wings, and transverse striation on the lateral wings and spathe, suggesting a different origin for the two parts. Although no definite boundary line between spathe and perianth could be traced in the complete specimens, the presence of such a boundary is clearly indicated by the oblique dying out of the lateral wings and the change in direction of striation. The living *Ottelia* is thin and flimsy in texture ; an impression would probably show no definite boundary line between spathe and perianth.

Saporta figures a leaf under the name *Ottelia parisiensis* from the Eocene of the Paris Basin (1879, p. 227, fig. 45).

V.17007 Holotype, figured Pl. IV, fig. 11. Impressions of two stalked fruits showing spathe and calyx segments. Remains of two other specimens are also seen on the stone.

V.17550 Figured Pl. IV, fig. 12. Impression of fruit showing spathe with lateral wings and one (or two ?) calyx segments.

V.17920 Poor impression of spathe and stalk.

Genus **STRATIOTES** Linnaeus

1753 Spec. Pl., ed. 1, p. 535.

Stratiotes neglectus Chandler

Plate IV, figs. 13, 14.

1923 *Stratiotes neglectus* Chandler : *Quart. Journ. Geol. Soc.*, lxxix, p. 126, pl. v, figs. 4, 27, 28 ; pl. vi, fig. 24.

DIAGNOSIS : Seed oblong or sub-oval, micropyle basal or sub-basal, slightly oblique, hilum dorsal near the base, raphe marginal

to the middle of the dorsal side, thence diagonal; diagonal portion usually more concave towards the interior than in *S. acuticostatus*; cells of the interior of the keel tortuous and convolute.

DESCRIPTION: Seed oblong or sub-oval, hooked at the base, flattened; keel moderately broad to narrow, not continued round the base, merging gradually into the collar, which is large, prominent, rounded, smooth or slightly rough; testa thick, woody, with irregular longitudinal tubercles often coalescing to form longitudinal ridges; ridges rarely continued on to the collar, frequently present, although less well-defined, on the keel, in well-preserved specimens sharp and thin, and finely striate at the edges; pitting of surface fairly coarse; micropyle basal or sub-basal, slightly oblique; hilum dorsal, near the base; raphe marginal from the hilum to the middle of the dorsal side, thereafter diagonal to the apex, where it enters the seed cavity. The curvature of the diagonal portion is such that the width of testa external to the raphe is usually less than the width of testa on its inner side; digitate cells of the interior of the keel tortuous and convolute. Length 5 to 8.5 mm.; breadth 2.5 to 3.5 mm. Actual seeds, external casts, and internal impressions.

In the specimens originally described, the ribs were less sharp than in some examples which have now been seen, and the collar was always perfectly smooth. The description has been slightly modified in accordance with this new evidence. Probably a smoother, more rounded appearance is due to wear and tear, and the sharper ridges and rougher collar now described represent the original condition of the seed.

The species is very common in the Bembridge Marl, both at Gurnard Bay, Thorness Bay, and Hamstead Ledge. It occurs in clays, marls, and clay-ironstone nodules.

V.17551 Figured Pl. IV, figs. 13, 14. Seed split in halves longitudinally, one half figured to show exterior, the other to show interior.

V.17921 Seed split in half with tegmen of same lying loose.

V.17922-36 Blocks with numerous specimens showing external casts, internal impressions of seeds, and remains of actual seeds.

Family GRAMINEAE

The family Gramineae is represented by a number of fragments of uncertain affinity. Among them there are a well-preserved cataphyll and several incomplete ribbon-like leaves.

Genus ? sp. 1

Plate IV, figs. 15, 16.

Leaves large, ligulate, with or without a conspicuous midrib, with numerous parallel nerves of equal strength connected by close transverse nervules. Length incomplete; breadth 25 to about

50 mm. The broadest specimen measures 25 mm. from margin to midrib, indicating a complete breadth of about 50 mm. Impressions, with shreds of organic matter especially on the nerves.

These large leaves probably all belong to a single genus of large habit, such as *Bambusa* or *Arundo*, but from fragmentary vegetative organs alone we cannot make any definite determination.

V.17552 Figured Pl. IV, fig. 15. Fragment of a large leaf (impression).

V.17553 Figured Pl. IV, fig. 16. Fragment of a leaf showing clear nervation, and counterpart.

V.17034 Two fragments of large leaves.

V.17937 Fragment of a large broad leaf.

V.17938-45 A number of fragments of leaves.

Genus ? sp. 2

Plate IV, fig. 17.

The blade of a ligulate leaf which gradually narrows to the apex, probably with a portion of the sheathing base. Surface of leaf puckered as if shrivelled. Nervation parallel, with fairly close nerves all of equal strength and equally spaced, without conspicuous transverse nervules. Length of blade 95 mm. ; breadth 12 mm.

This impression apparently belonged to a smaller plant than the preceding specimens, with a different nervation.

V.17554 Figured Pl. IV, fig. 17. Impression of leaf-blade.

Genus ? sp. 3

Plate IV, fig. 18.

Cataphyll (perfect) lanceolate, acutely pointed at the apex, with strong parallel nerves rather widely spaced. Length 21 mm. ; breadth 4.5 mm. This impression greatly resembles the cataphylls of Gramineae and belongs to a fairly small plant. It should perhaps be associated with sp. 2, but in the absence of definite evidence we have not united them.

V.17555 Figured Pl. IV, fig. 18. The only specimen.

Gramineae ?

V.17011 Fragment of node.

V.17035 Fragment of a larger node.

Besides the above organs, there are numerous impressions showing fragments of roots, rhizomes, scars, etc. Some of these may belong to Gramineae, but we were unable to obtain satisfactory proofs of this relationship. Specimens are therefore figured among the plants of unknown relationship (see pp. 163, 164).

Family **CYPERACEAE**Genus **CAREX** Linnaeus

1753 Spec. Pl., ed. 1, p. 972.

Carex gurnardi n. sp.

Plate IV, fig. 19.

DIAGNOSIS: Utricle small, shining, without ribs, closely investing the nut; nut ovoid, thimble-pitted.

HOLOTYPE: V17556.

DESCRIPTION: *Utricle*: Imperfect, shining, closely investing the nut, without the conspicuous ribs seen in many species of *Carex*.

Nut: Small, ovoid, originally inflated (now deflated and with the sides in contact); surface ornamented with small pits aligned longitudinally, which produce thimble-pitting.

Length 1.25 mm.; breadth 0.5 mm.

An impression with fragments of the utricle and a second specimen of an actual nut.

The form and thimble-pitting of this nut are typical of Cyperaceae, more especially of *Carex*.

V.17556 Holotype, figured Pl. IV, fig. 19, shows the nut.

V.17946 A badly preserved nut showing pitting, associated with, and attached to, part of a utricle.

V.17947 Utricle.

Carex? sp. 2

Plate IV, figs. 20, 21.

Utricle lanceolate-oval, truncate at the base and bifurcate at the extreme tip, somewhat flattened, with irregular longitudinal grooves and ridges. Surface ornamentation of deep pits (papillae on the impressions), more or less elongate and aligned longitudinally. Length 8 mm.; breadth 2 mm. Represented by impressions (counterparts).

The impression of a raised median ridge seen on one counterpart is probably due to distortion, as the cell-structure is continuous over it, and undifferentiated.

V.17557 Figured Pl. IV, figs. 20, 21, may represent the utricle of a large *Carex*.

Cladiocarya foveolata n. gen. et sp.

Plate IV, figs. 22, 23.

DIAGNOSIS of genus and species: Nut urceolate, bisymmetric, with two longitudinal ridges, and with a truncate neck closed by

a plug. Surface with conspicuous depressions aligned longitudinally. Possibly with a glume or utricle.

HOLOTYPE : V.17558.

DESCRIPTION : Nut urceolate, bisymmetric, tapering at one end to a point, with a prominent, truncate neck at the other. Two longitudinal ridges run down opposite sides, they are fairly inconspicuous at the neck, but produce a bisymmetric broadening at the pointed end. Neck plugged by a mass of soft tissue carrying a central strand of fibres ; surface with large conspicuous depressions aligned in longitudinal rows. Length 1.5 mm. ; breadth 0.7 mm.

One perfect nut and several impressions.

The impression of one fruit seems to lie on that of a glume or utricle, which is longer than the nut, and narrowed to a point. The nut shows a tendency to split along the lateral rims into symmetric halves, and this tendency, together with the general form, leads us to think that the specimens are fruits rather than seeds.

AFFINITIES : Certain genera of Cyperaceae have somewhat similar urceolate nuts—*Cladium*, *Hypolytrum*, and *Chorisandra*, for example. In these the plugged neck is the base. In *Cladium*, the nut is pointed at the apex, and smooth, but it is inconspicuously lobed with strands of fibres (about five) in the furrows between. It is symmetric about more than two planes. *Hypolytrum* has a basal neck with plug, a pointed apex, and sharp longitudinal ribs. It is bisymmetric with a lateral rim, like the fossil. *Chorisandra* has longitudinal rows of large, deep pits, but the sculpture is more regular and the fruit shows complete symmetry. All the above genera have utricles.

The evidence seems to place the fossil with Cyperaceae, but we cannot suggest any definite position in the family.

V.17558 Holotype, figured Pl. IV, figs. 22, 23. Impression of nut on block, and nut removed from block.

V.17948 External impression of nut.

V.17949 Three impressions of nuts ; *Potamogeton pygmaeus* on same block.

V.17950 A good impression of nut ; *Limnocarpus spinosus* on same block.

V.17951 Two specimens' (poor).

V.17952-54 Good impressions of nuts.

V.17031 Cast showing plug.

Family **PALMAE**Genus **SABAL** Adanson

1763 Fam. Pl., II, p. 495.

Sabal major (Unger)

Plate IV, fig. 26.

- 1847 *Flabellaria major* Unger, *Chloris protogaea*, p. 42, pl. xiv, fig. 2.
 1853 *Flabellaria major* Unger: Ettingshausen, *Abhandl. geol. Reichsanst., Wien*, ii, p. 33, pl. iii, figs. 3-7.
 1855 *Sabal major* (Unger): Heer, *Fl. Tert. Helv.*, i, p. 88, pl. xxxv, pl. xxxvi, figs. 1, 2.
 1860 *Sabal major* (Unger): Gaudin & Strozzi, *N. Denkschr. Schweiz. Naturf. Ges.*, xvii, 4, p. 38, pl. i, fig. 14, pl. ii, fig. 16.
 1865 *Sabalites major* (Unger): Saporta, *Ann. Sci. Nat., Bot.*, (5) iii, p. 82, pl. ii.
 1870 *Sabal major* (Unger): Schimper, *Traité Pal. Vég.*, ii, p. 487, pl. lxxxii, fig. 1.
 1888 *Sabal major* (Unger): Gardner, *Rep. Brit. Assoc.* (1887), p. 423, pl. v, fig. 2.
 1891 *Sabal major* (Unger): Saporta, *Mém. Soc. Géol. France*, ii, p. 29, pl. vi, fig. 1.
 1899 *Sabal major* (Unger): Laurent, *Ann. Mus. Hist. Nat. Marseille*, (ii) i, p. 62, pl. ii, pl. iii, figs. 1, 2.

DIAGNOSIS: Leaves large, palmate, with adherent ligule free at the margin, and rachis as in *Sabal*.

REMARKS: The leaf of a fan-palm was obtained from the Bembridge marls by Gardner, and figured by him as *Sabal major* (1888). No description of it is given, but the figure shows the central portion of a large frond with a wide petiole narrowing into an elongate rachis. About forty-two pinnules can be counted in the figure, chiefly arising from the basal part of the rachis, but a few are given off along the narrow elongate portion. This leaf, which is in the Museum of Practical Geology, Jermyn Street, is undoubtedly a *Sabal*. It apparently represents an impression of the lower surface.

In the same paper (p. 418) Gardner mentions a second specimen which he was unable to remove from the matrix. It had a radius of 2 feet 4 inches, and was even then imperfect; the leaf-stalk measured 2 inches across, was smooth and angular at the back.

A fragment of *Sabal major* also exists in the A'Court Smith collection.

DESCRIPTION: Leaf (incomplete) large, asymmetric, petiole slightly concave above, lamina with about fourteen pinnules preserved, while there must have been many more in the complete leaf; ligule large, triangular, adherent to the upper side of the rachis, with conspicuous upstanding edges, passing imperceptibly

into the petiole below. Length and breadth imperfect; breadth of ligule 30 mm.

Impression of the upper surface.

The specimen is a mere fragment, preserved in a clay-ironstone nodule. The prominent edges of the ligule have formed deep grooves in the impression (see figure).

Our examination of palms in Kew Gardens and Herbarium showed that such an impression could only be made by the upper side of a leaf with a large adherent ligule such as occurs in *Sabal* and but few other genera. As already stated, Gardner's figure agrees with the lower surface of *Sabal*.

Sabal major (Unger) has been commonly recorded from strata of Oligocene and Miocene Age.

V.17560 Figured Pl. IV, fig. 26, is the fragmentary leaf impression described above.

Genus **PALMOPHYLLUM** Conwentz

1886 Flora des Bernsteins, II, p. 11.

Palmophyllum sp.

Plate IV, fig. 27.

Leaf palmate, large, with a broad petiole and close-set pinnae; lamina with a long, narrow, triangular rachis from which the pinnae are given off. There is no sharp line of demarcation between pinnae and rachis; about forty-two pinnae are visible. Ligule free, probably upstanding, its line of junction with the petiole broad and slightly convex upwards.

Breadth of petiole about 30 mm.

The leaf is represented by counterparts, the impression of the upper surface being seen on the larger fragment. The limiting edge below marks the line of junction of the ligule. Of the lower surface, one side only of the rachis is preserved. The leaf is too fragmentary for identification, but its morphology, so far as it can be seen, recalls *Copernicia* and *Latania*.

V.17561 Figured Pl. IV, fig. 27, a fragment of a lamina, with counterpart.

V.17955 An unidentified fragment of a palm, too incomplete for determination or description. Twigs of *Araucarites* and leaves, probably of *Sparganium multiloculare*, occur on the same block.

Palaeothrinax Mantelli n. gen. et sp.

Plate V, figs. 1-5.

1851 *Palmacites Lamanonis* Brongniart: Mantell, Petrifications and their Teachings, p. 52, fig. 17.

1854 *Palmacites Lamanonis* Brongniart: Mantell, Geological Excursions round the Isle of Wight, p. 310, fig. 37.

1888 *Flabellaria Lamanonis* (Brongniart): Gardner, *Rep. Brit. Assoc.* (1887), pp. 418, 423, pl. v, fig. 1.

DIAGNOSIS of genus and species: Leaf small, palmate; petiole unarmed; pinnae from 33 to 44 with thickened margin but no visible midrib; rachis almost wanting; ligule sub-triangular.

Distinguished from *Thrinax* by the absence of midrib and by the presence of the very short rachis.

HOLOTYPE: 38358.

DESCRIPTION: Leaf small, palmate; petiole unarmed, thin and flat (probably the effect of fossilisation, as the whole leaf is flattened); lamina multiplicate at the base, multifid towards the margin (apices of pinnules not seen); number of pinnae thirty-three to forty-four; angle of spread of lamina about 120° ; pinnae with thickened margins (Pl. V, fig. 1) but no marked midrib, and with a series of parallel nerves alternating with one or more subsidiary nerves.

Lower Surface of Leaf: Petiole very shortly triangular at the apex, forming a very short rachis (Pl. V, figs. 4, 5).

Upper Surface: Petiole convex at the apex, but prolonged above into a sub-triangular asymmetric ligule (Pl. V, figs. 1, 2, 3).

Length of frond incomplete (greatest length preserved 274 mm.); breadth of pinnae 9–12.5 mm.; breadth of petiole at insertion of lamina (38358) 18 mm.

AFFINITIES: These two specimens have both been previously ascribed to Brongniart's species *Palmacites Lamanonis*, 38358 by Mantell, and V.1848 by Gardner. The latter is an impression with organic substance. Mantell states that his specimen is from the freshwater Tertiary deposits at Whitecliff Bay, and that it occurred in a fallen block of fawn-coloured limestone. The matrix appears to us to be the ordinary clay-ironstone of the Bembridge marls. The authors of the Survey Memoir (Bristow, etc., 1889, p. 169) commenting on the specimen, say that it was stated to come from the "Bembridge Limestone near Foreland Pt., but the specimen is in an ironstone nodule." Gardner's specimen (V.1848) is preserved in soft white Bembridge marl associated with *Cyrena pulchra*. The exact horizon is not mentioned.

Towards determining the relationship of this palm the most important characters are the apex of the petiole and form of the ligule. The ligule in 38358 (fig. 1) shows definitely that this specimen is an impression of the upper surface. When the carbonaceous substance is chipped away at the top of the petiole in V.1848 (fig. 4) the impression of the ligule appears below it, proving clearly that the organic substance shows the actual lower surface of the leaf, and that the underlying impression represents the upper surface. Gardner's figure does not show this underlying impression, and he represents continuous organic substance. It therefore follows that

the scaling off of the carbonaceous layer, revealing new evidence, must have occurred since he figured the specimen.

We have examined all living species of palms in Kew Herbarium and Gardens, and find that *Thrinax* alone is comparable with this species. We have seen all the characters of the fossil in this genus, except the very short rachis and the absence of midrib, although all are not common. The conical end of the rachis on the lower side of *Thrinax* is never quite so long as in the fossil. The general form and texture of the leaf, the form of the ligule, the number of pinnae and their thickened margins are all characteristic of *Thrinax*. The most aberrant character of the fossil is the absence of a midrib. In the impressions of the upper surface this would not be remarkable, for on many living *Thrinax* leaves the midrib is very inconspicuous on this side of the leaf. On the lower surface, however, the midrib is prominent in *Thrinax*. This difference of nervation and the somewhat more elongate rachis are the only characters which appear to separate the Bembridge palms from *Thrinax*. The question therefore arises as to the desirability of referring the fossil to the recent genus *Thrinax* or of leaving it in the indefinite group genus *Flabellaria*, where its relationship to the living is obscured. We think the difficulty is best met by creating a new genus *Palaeothrinax*.

Of other fossil species the nearest is undoubtedly *Flabellaria Lamanonis* from Aix (Brongniart, 1822, p. 311, pl. iii, fig. 1; Saporta, 1862, p. 223, pl. iv, fig. 5). This species is similar in its rounded or shortly conical apex to the unarmed petiole, in the similar spread of leaf and character of lamina and nervation, a midrib being absent here also. It differs in its greater number of pinnae (55 to 61) and apparent absence of ligule; for this structure has never been described. Moreover, de Saporta states that it shows a distant relationship to *Chamaerops* and *Thrinax*, but differs in essential characters, although he does not specify these. But *Chamaerops* has no marked ligule such as we have described, also it has a greater spread of leaf, and an armed petiole which ends bluntly at the apex. The number of pinnae in different species of *Thrinax* varies considerably, but we have not seen so great a variation on any one species as from 33 to 61, which amalgamation with *Flabellaria Lamanonis* would entail. In view of these facts, and especially of the apparent absence of ligule in *F. Lamanonis*, we cannot refer the Bembridge leaves to that species with any confidence, and therefore give the new specific name *P. Mantelli*, after the author who first recorded this plant.

38358 Figured Pl. V, figs. 1-3, also figured Mantell, *loc. cit.*, the impression of the upper surface of a leaf.

V.1848 Figured Pl. V, figs. 4, 5, also figured Gardner, *loc. cit.*, a carbonaceous leaf showing the lower surface; the carbon has scaled away in parts and the specimen there shows the impression of the upper surface.

38359 A fragmentary impression of several pinnae, too poor for description.

Family ARACEAE

Genus *EPIPREMNUM* Schott

1857 *Bonplandia*, V, p. 45.

Epipremnum ornatum n. sp.

Plate IV, figs. 24, 25.

DIAGNOSIS: Seed curved-cylindrical, with a thick testa which has a longitudinal depression along the middle of its convex edge, and is ornamented with concentric rows of large, deep, conspicuous pits.

HOLOTYPE: V.17559a.

DESCRIPTION: Seed albuminous, semi-anatropous, curved-cylindrical, with a conspicuous basal hollow and a depression along the opposite convex edge. Micropyle at the end of one limb, large, gaping, closed by a plug of loose tissue; chalaza at the end of the other limb; hilum represented by a small aperture within the basal hollow near the chalaza. Testa thick, finely punctate, ornamented with conspicuous large pits arranged concentrically, one row of which occurs along the marginal depression, composed of honeycomb cells which become more compact towards the interior. Seed-cavity curved, sausage-shaped, with a smooth, shining lining, finely striate transversely. At one end of the cavity the chalaza shows as a circular, brown, stain from which the cells radiate. Length 3 to 3.5 mm.; breadth 2 mm.

One actual seed, several external impressions, and one internal cast combined with the remains of the actual seed.

AFFINITIES: Of living species we have seen the seeds of *Epipremnum pinnatum* Engl., *E. mirabile* Schott, and *E. giganteum* Schott. They are all of the same shape as the fossil, but the testa, although hard and woody, is not so thick in the living species; it shows the same concentrically arranged pits. The hilum and micropyle are placed as in the fossil, and the cavity is almost identical in appearance. The genus *Epipremnum* chiefly inhabits the Malay Peninsula and East Indies, but ranges also into Australia, China, Formosa, and the Philippines. In Yunnan (S. China) a climbing species is found at heights of 4,500 and 7,000 feet.

The genus was first recorded fossil from the Lower Pliocene of Reuver (C. & E. M. Reid, 1915, pp. 71, 72, pl. iv, figs. 1-9). Later, the same species, *E. crassum* C. & E. M. Reid, was found in the Lower Pliocene of Pont-de-Gail, Cantal (Reid 1920b, p. 63, pl. iii, figs. 13-16). The Bembridge species, although it resembles *E. crassum*, differs in some important specific characters. The seed is curved-

cylindrical, and grooved at the outer convex margin ; in *E. crassum* it is not grooved and is reniform. Further, its walls are thicker and the pits more numerous and deeper than in *E. crassum*. We believe that the coarse cells of the testa point to a semi-aquatic habit such as is found in some living representatives of the genus.

V.17559 A block of stone showing the following :

(1) An external impression of a seed from which the holotype, V.17559a, figured Pl. IV, fig. 24, was removed. This seed, slightly broken at either end, shows the cast of the cavity.

(2) Specimen figured Pl. IV, fig. 25. An external impression showing concentrically placed tubercles, which are the casts of large pits on the actual seed, and a large cylindrical cast of the micropylar opening ; also a rounded projection on the concave margin which is the cast of the basal hollow.

(3) A seed broken longitudinally so as to show, lying within, a cast of the seed cavity covered by a thin shining skin. At the thicker end the micropyle can be seen, and at the thinner end the discoloured chalaza-scar.

Family ZINGIBERACEAE

Genus **SPIREMATOSPERMUM** Chandler

1925 Upper Eoc. Flora, p. 17.

Spirematospermum Wetzleri (Heer)

Plate V, figs. 6, 7.

- 1859 *Gardenia Wetzleri* Heer, Flora Tert. Helvet., iii, p. 192, pl. cxli, figs. 81-103.
- 1860 *Passiflora Braunii* Ludwig, *Palaeontographica*, viii, p. 124, pl. xlviii, figs. 11-16.
- 1862 *Gardenia Wetzleri* Heer : *Phil. Trans. Roy. Soc.*, clii, p. 1069, pl. lxix, figs. 1-8.
- 1888 *Gardenia* (?) *Wetzleri* Heer : Gardner, *Rep. Brit. Assoc.* (1887), p. 422, pl. iii, figs. 11-15.
- 1913 *Carpolithes Wetzleri* (Heer) : Menzel, *Jahrb. Preuss. Geol. Landesanstalt*, xxxiv, p. 12, pl. ii, figs. 1-8.
- 1920 *Carpolithes Wetzleri* (Heer) : Kräusel, *Jahrb. Preuss. Geol. Landesanstalt*, xxxix, p. 392, pl. xxv, figs. 20-25.
- 1925 *Spirematospermum Wetzleri* (Heer) : Chandler, Upper Eoc. Flora, p. 17, pl. i, figs. 8a-c.

DIAGNOSIS : Fruit (not known from Bembridge) a many-seeded capsule (? two-loculed). Seed oblong, anatropous, with a deep basal depression for the micropyle and hilum ; micropyle closed by a plug ; testa thick, black, shining, and ornamented with close, fine, spiral striae.

DESCRIPTION : Seed oblong, rounded at the apex, truncate at the base, with a deep basal depression ; testa black and shining, with fine spiral striae, thick. Three actual seeds embedded in

rock fragments, one perfect. The fruits have not been found in the Bembridge beds. Length of perfect seed 5.5 mm.; breadth 2 mm.

AFFINITIES: The correctness of Heer's original ascription of this genus to *Gardenia* has long been doubted, although the true relationship remained unknown. In 1925, after an elaborate study of fruits and seeds from Hordle, they were shown to belong to the family Zingiberaceae, but they could not be referred to any living genus. A new generic name, *Spirematospermum*, was therefore given. The Lower Headon material was more abundant and better preserved than the Bembridge, so that the anatomy of the seeds could be better studied. They were shown to be anatropous with a lateral raphe and large apical chalaza. The hilum was seen in the wall of the deep basal depression, at the bottom of which was the large micropyle closed by a thin circular plug.

The Bembridge seeds are identical in appearance with those from Hordle. *Spirematospermum* is also known from the Bovey Tracey Lignite (Heer, 1862a), perhaps also from the Hamstead beds, Isle of Wight, and from many European localities—Samland, Silesia, Bavaria, Wetterau, and Rhön (see synonymy above).

V.17562 Figured Pl. V, fig. 6. Seed (perfect).

V.17563 Figured Pl. V, fig. 7. Seed (broken) showing spiral striation very clearly.

V.17956 Seed (imperfect). Also three *Sparganium* fruits.

Genus **COSTUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 2.

? **Costus** sp.

Plate V, figs. 8, 9.

DESCRIPTION: Leaf fragmentary, with a broad mid-rib, prominent on the lower surface, from which secondary nerves arise at acute angles and run parallel with one another; as the nerves pass upwards and outwards, the angles they make with the midrib become wider, until ultimately they are about 25°. The secondary nerves are connected by close, oblique tertiary nerves which are sub-parallel, and inclined to the midrib at about 85° (measured in the apical direction); occasionally they bifurcate. The surface of the lamina in some specimens is closely beset with small, dark, usually oval dots; in addition, there are larger and fewer round dots, possibly associated with hair-bases. Such specimens probably represent impressions of the upper surface. Impressions only. Length and breadth incomplete; breadth of midrib about 1.75 mm.; distance between secondary nerves from 1 to 1.5 mm.

DISCUSSION: The family Marantaceae displays a somewhat similar nervation, but the angle between secondaries and mid-rib

contracts as the nerves sweep outwards and upwards ; also, the tertiary nerves make angles greater than 90° with the midrib (measured on the apical side of the nerves).

The genus *Costus* (Zingiberaceae) has nervation exactly similar to that of the fossil ; it also possesses thickly scattered glandular dots, and a few round tufts of hairs on the upper surface. The mid-rib is prominent on the lower surface. It appears probable, therefore, that both surfaces of a leaf of *Costus* are represented in the Bembridge beds.

Costus is a tropical genus chiefly found in America and West Africa, but occurring also in Asia from China to Australia.

The question naturally arises whether the seeds of *Spirematospermum Wetzleri* (see p. 84) should be associated either with these leaves or with those next described. On this point there is no decisive evidence ; the seeds of *Spirematospermum* are quite distinct from those of *Costus*, *Amomum*, *Strobidia*, or any other genus in the family that we have been able to examine.

From Samland, Heer (1869) described fruits and seeds of *S. Wetzleri*, also leaves which he regarded as identical with those of *Globba*. Judging from his figures, these resemble the leaves of *Costus* rather than *Globba*. As no other representative of the family Zingiberaceae was recorded from the locality, it seems possible that these leaves, which he names *Zingiberites borealis*, as well as the Bembridge leaves, may be those of *S. Wetzleri*. We do not feel that the evidence of the broken Bembridge fragments is sufficient to warrant a definite ascription either to *Costus*, or to *Zingiberites borealis*.

V.17564 Figured Pl. V, fig. 8. Impression of lower surface of leaf.

V.17565 Figured Pl. V, fig. 9. Fragment of leaf showing nervation very clearly.

V.17957-59 Three fragments of leaf impressions.

Genus ? (ZINGIBERACEAE)

Plate V, figs. 10, 11.

Leaf imperfect, with a broad mid-rib prominent on the lower side, sunk on the upper, and a close series of secondary nerves emerging at acute angles. These nerves run parallel to one another at angles of about 20° with the midrib, producing a closely striate surface. Connecting nervules occur between the secondaries, approximately at right angles to them. Length and breadth incomplete. Impressions.

We have found leaves of this character in species belonging to the genera *Amomum*, *Strobidia*, *Curcuma*, etc., of the family Zingiberaceae, but the evidence is insufficient for determining to which, if to any, of these the fossil is related.

V.17566 Counterparts, figured Pl. V, figs. 10, 11 ; fig. 10, lower surface ; fig. 11, upper surface.

V.17960-63 Fragments of leaves.

Family ?

MONOCOTYLOPHYLLUM nom. nov.

For monocotyledonous leaves of uncertain affinity.

Monocotylophyllum sp. (Gramineae ? § Bambusae ?)

Plate V, fig. 12.

Leaf (fragment only) with a long pedicel hollowed towards the lower end as though ultimately clasping the stem; lamina markedly striate, striae of uniform thickness, fanning out from the midrib at the base, but ultimately running parallel with it; secondary nerves not seen. On the left the lamina is intact, but on the right it is torn into shreds which lie embedded in the stone. Texture thick and stiff. Length of fragment (including pedicel) 38 mm. Impression of the lower surface with remains of organic substance.

The leaf is clearly a monocotyledon, and in its nervation is similar to some bamboos. We have not, however, seen any with such long stalks, although the leaves of *Arundinaria* are shortly stalked.

V.17567 Figured Pl. V, fig. 12, is the only representative. The apparently triangular apex of the stalk is an accident due to secondary deposition of mineral matter.

Class DICOTYLEDONES

Family JUGLANDACEAE

Genus ENGELHARDTIA Leschenault

1825 ex Blume, Bijdr. Fl. Ned. Ind., p. 528.

Engelhardtia macroptera (Brongniart)

Plate VI, figs. 1-6, text-fig. 5.

- 1828 *Carpinus macroptera* Brongniart, *Ann. Sci. Nat.*, xv, p. 48, pl. iii, fig. 6.
- 1851 *Carpinus macroptera* Brongniart: Unger, *Denkschr. Ak. Wiss. Wien*, ii, p. 164, pl. xxxii, figs. 1-3.
- 1851 *Carpinus producta* Unger, *loc. cit.* p. 164, pl. xxxii, figs. 4-6.
- 1852 *Carpinus grandis* Unger, *op. cit.* iv, p. 111, pl. xliii, figs. 2-5.
- 1852 *Carpinus oblonga* Unger, *tom. cit.* p. 112, pl. xliii, fig. 17.
- 1858 ? *Engelhardtia sotzkiana* Ettingshausen, *Sitzber. Ak. Wiss. Wien*, xxviii, p. 539, pl. iv, fig. 4.
- 1863 *Engelhardtia decora* Saporta, *Ann. Sci. Nat., Bot.* (4) xix, p. 93, pl. xi, fig. 1.
- 1865 *Engelhardtia Brongniartii* Saporta, *Ann. Sci. Nat. Bot.* (5) iv, p. 199, pl. xii, fig. 5.

- 1865 ? *Engelhardtia oxyptera* Saporta, *Ann. Sci. Nat. Bot.* (5) iv, p. 200, pl. xii, fig. 2.
 1866 *Engelhardtia macroptera* (Brongniart): Unger, *Denkschr. Ak. Wiss. Wien*, xxv, p. 52, pl. xvi, figs. 9-11.
 1869 *Engelhardtia Brongniartii* Saporta: Ettingshausen, *Denkschr. Ak. Wiss. Wien*, xxix, p. 48, pl. liii, figs. 3-8.
 1869 *Engelhardtia macroptera* (Brongniart): Unger, *Denkschr. Ak. Wiss. Wien*, xxix, p. 157, pl. v, fig. 13.
 1874 *Engelhardtia Brongniarti* Saporta: Schimper, *Traité*, iii, p. 263, pl. cii, figs. 23-27.
 1877 *Engelhardtia Brongniartii* Saporta: Ettingshausen, *Denkschr. Ak. Wiss. Wien*, xxxvii, p. 199, pl. xvii, figs. 4-7.
 1922 *Engelhardtia Brongniartii* Saporta: Engelhardt, *Abhand. Hess. Geol. Landesanst.* Darmstadt, vii, p. 104, pl. xxxiv, fig. 10.

DIAGNOSIS: Involucre large, deeply 4-fid; median lobe, long-oval to lanceolate-spathulate; lateral lobes shorter, more oblong and asymmetric; small lobes large for *Engelhardtia*, lamellate above, semicircular to broad ligulate, margin entire; nervation of the large and the lateral lobes similar, with a pair of lateral nerves flanking the midrib below; small lobe with a sub-parallel series of nerves arising from the base, bifurcating above, and then anastomosing; nut ovoid, smooth, covered with numerous raised, discoid, glands, showing stellate structure.

DESCRIPTION: *Involucre*: large, deeply 4-fid, lobes united for a distance greater than that of the nut, usually somewhat expanded and reflexed, enclosing the fruit. Median lobe elongate, varying from long-oval to lanceolate-spathulate, broadest above or at the middle, symmetric, apex rounded, margin entire; lateral lobes shorter than the median, more oblong and more asymmetric; fourth lobe relatively small, but large for *Engelhardtia*, about twice as long as the nut (exclusive of the perianth), free part above the nut as broad as long, or rather broader, varying from semicircular to broad-ligulate, margin entire, rounded; surfaces beset with discoid glands. Nervation of the three large lobes similar in character, but differing in detail, prominent on both surfaces; median lobe with a strong midrib continued to the apex, flanked on either side by a lateral longitudinal nerve which arises from the base and loops with the secondaries about half-way up; secondary nerves few, emerging from the midrib alternately in the upper half of the lobe at angles which become more obtuse towards the apex, concave upwards, and uniting to form conspicuous submarginal loops; midrib and laterals connected by a series of short nerves which form angles or arches with convexities towards the apex, and with their highest points nearer to the laterals than to the midrib; tertiary nerves, arising from the laterals and forming submarginal loops, very variable both in direction and thickness, and sometimes scarcely distinguishable from the irregular quaternary nerves which form a network over the whole wing. The

nervation of the lateral lobes differs from that of the median only in its greater irregularity; the midrib is not so straight and symmetrically placed, and the lateral nerves are less defined. The nervation of the small median lobe is unlike that of the other three;



FIG. 5.—*Engelhardtia macroptera* (Brongn.). *a*, V.17674, $\times 2.5$; *b*, V.17675, $\times$ nearly 2.5. Two camera lucida drawings to show the variation in form and nervation of the involucre. *c*, Diagrammatic drawing of the impression of a nut (apex), showing the hollows for the style and four perianth segments, and the distribution of the discoid glands (dots), $\times 4$.

it sometimes has a strong median or sub-median nerve with several subsidiary laterals, or all the primary nerves may be equally pronounced, forming a sub-parallel series; whatever the arrangement,

the primaries bifurcate at angles of about 35° , and the branches unite and ultimately form a network at the apex of the lobe; the position of bifurcation varies. Length of large median wing measured from the base of the fruit 42 to 45 mm.; breadth 7.5 to 10 mm. Length of lateral wings, also measured from the base of the fruit, 23 to 27 mm.; breadth 5.5 to 6 mm.; length of small median wing (free part) 7 to 7.5 mm.; breadth 8.5 to 10 mm. Impressions.

Nuts: Sub-globose or ovoid, narrowed below and above, small, occasionally with longitudinal ribs which may represent the remains of the adherent involucre; thickly beset with discoid glands showing a stellate structure (Pl. VI, figs. 4, 5). Calyx lobes four, persistent, ligulate, erect or incurved; style long, only the basal part seen. Length of fruit without perianth 5 mm.; breadth 3.25 to 3.5 mm.; length of perianth 2.5 mm.; breadth of segments 0.75 mm. Preserved as casts with fragmentary organic substance, and one specimen with the actual glands perfect.

Impressions of the apex of the nut show a central cavity (the cast of the style) surrounded by four symmetrically placed curved cavities (the casts of the perianth); the whole surface is covered with little pits (the casts of the discoid glands).

None of the numerous specimens is quite perfect, but this is usually due to the fracture of the stone, part of the specimen having been lost either in erosion or in process of collecting. About twenty specimens show the relation of the parts and about twelve show the small wing. Measurements of the angles between the midribs of the lateral lobes were made in seven specimens. In three they measured 140° , in four others 105° or 90° .

AFFINITIES: We have compared the fossils both with *Oreomunnea* and *Engelhardtia*. From the former, which is well represented by fruiting specimens in Kew Herbarium, they differ in size, texture, shape (particularly in the widening of the middle lobe towards the base in *Oreomunnea*), relative proportions, and angle between the wings; also in the midrib, which does not reach the apex of the large lobe, and in the secondary nerves which are usually convex, not concave, upwards. In the character of the small lobe, the presence of marked lateral nerves, and the nervation of the side lobes, the resemblance is strong. In all the characters referred to, with the exception of the last three, the fossils resemble *Engelhardtia* much more closely; and even these last characters can occasionally be found within the genus.

A study of living species shows that size varies greatly according to the position on the inflorescence, and that the three large lobes vary in size and form not only in different species, but in different specimens of the same species. For example, in *E. spicata* Blume, the median lobe may be long and slender, or clumsy and scarcely longer than the laterals; in *E. Wallichiana* Lindley, it may vary from rounded-oblong to slender-spathulate: and so with other

species. Certain groups can be distinguished by the nuts, some being glandular and without hairs, others hairy. The large median lobes have secondary nerves which form a marked system of lateral loops throughout; usually the secondaries are given off at angles of about 60° , but in *E. Wallichiana* they may be as small as 30° .

The small lobes show more specific distinctness than the large, and less individual variation. In *E. Wallichiana* and *E. simplicifolia* they are reduced to mere frills; in *E. serrata* Blume and *E. parviflora* C. de Candolle they are two-lobed; in *E. aceriflora* Blume they are entire and ligulate; in *E. nudiflora* Hooker var. *crenata* they are deeply three-lobed, and so on. Taken in conjunction with other characters, the nature of the small lobe is of the greatest value in determining species, and is therefore of particular importance in deciding whether or not more than one fossil species is represented in a deposit.

The Bembridge specimens show similar variations of form, size, relative proportions, and nervation to those found in living species. The small wing is always entire, and its variation scarcely exceeds that seen in the living. We therefore believe that all but one of the specimens should be referred to a single species. In the size and character of the small nuts, the fossil closely resembles *E. Wallichiana* and *E. simplicifolia*, which are smooth and covered with discoid glands, identical with those of *E. macroptera*. In nervation it is nearest to *E. spicata* in most of its characters, but they are seen individually in other species. Lateral nerves are very rare, but they sometimes occur in *E. Wallichiana*, *E. spicata*, and *E. javanica*. In the shape of the large wings it resembles *E. spicata* and *E. Wallichiana*, and in the entire margin of the small lobe it is like *E. aceriflora*, although this species has a more ligulate lobe than the fossil.

Engelhardtia fruits have often been recorded fossil, in Europe from Sagor, Sotzka, Radoboj, Parschlug, Bilin, Gergovie, Armissan, St. Zacharie, and other localities, and in America from the south-eastern United States. They were first thought to be *Carpinus* (Brongniart 1828a, Unger 1851). The credit of recognising the genus *Engelhardtia* in these fossils belongs to Ettingshausen, who made a preliminary statement to this effect in 1851 (p. 12), and amplified it on several later occasions (1858, 1869, 1877).

The Bembridge species exactly resembles *E. macroptera*, a species originally described by Brongniart (1828a) from Armissan, and later named *E. Brongniartii* by Saporta (1865). It was recognised at Bilin by Ettingshausen (1869), who grouped several of Unger's species of *Carpinus* (*C. macroptera*, *C. producta*, *C. grandis*, *C. oblonga*) under the name *E. Brongniartii*. As a result of our study of the range of variation in living species we think that Ettingshausen was fully justified in uniting these forms. We would also suggest that *E. oxyptera* Saporta from Armissan and

E. decora Saporta from St. Zacharie should probably be included in *E. macroptera*, as the characters on which Saporta divides them are individual rather than specific. Unfortunately, Saporta never seems to have recognised the small lobe. In the Bembridge material it is usually seen only as an impression superimposed on the impressions of the other bracts, or is sometimes preserved on counterparts when these have been saved. The Bembridge plant also bears a close resemblance to *E. puryearensis* Berry (1916, p. 185), from beds of Wilcox age in America, but not so close a one as to *E. macroptera*, with which Berry also compares his species.

- V.17012 Figured Pl. VI, fig. 1. Involucre showing 4 lobes.
- V.17568 Figured Pl. VI, fig. 2. Fruit with three sepals, large dorsal lobe complete, and portions of three others.
- V.17569 Lower part only figured Pl. VI, fig. 3. Fruit with two lobes, also counterpart (in two pieces).
- V.17570 Discoid gland from this specimen figured Pl. VI, figs. 4, 5. Fig. 4 shows the upper surface of a gland; fig. 5, the lower of another. The specimen shows apex of fruit, sepals, and fragments of the involucre; also organic glands on fruit.
- V.17674 Text-fig. 5a. Impression of fruit and involucre showing nervation.
- V.17675 Text-fig. 5b. Impression of involucre showing variation in nervation.
- V.17965 Impressions of three lobes (part of small lobe) and counterpart.
- V.17966 Fruit, with casts of sepals and style, lateral lobe (complete), part of dorsal lobe, and small lobe (complete).
- V.17967 Impression (poor) of ventral side of involucre showing four lobes.
- V.17968 Impression of fruit surrounded by involucre; counterparts show exterior.
- V.17969 Impression of fruit and parts of three wings; sepals showing indistinctly.
- V.17970 Fragments of two lobes and bad impression of fruit.
- V.17971 Large lobe with small lobe lying on it, and part of lateral lobes.
- V.17972 Parts of three lobes; large lobe nearly complete, small lying on it; with counterpart.
- V.17973 Fruit with parts of four lobes, and counterpart. The largest specimen of a small lobe that we have seen.
- V.17974 Small lobe and parts of two laterals, also impression of apex of fruit.
- V.17975-78 Four sets of counterparts showing portions of lobes of involucre.
- V.17979 Small lobe and counterpart.
- V.17980 Small lobe and fragment of lateral lobe.
- V.17981 Large lobe.
- V.17982 Fragment of large lobe and cast of fruit showing a few glands.
- V.17983 Impression of fruit and calyx, with glands.
- V.17984 Three specimens showing fragments of *Engelhardtia* and spores of *Azolla*.
- V.17985-87 Three specimens showing impressions of fruits.
- V.17008 Large dorsal wing.

V.17636 Catalogued under *Carpolithus* sp. 7, also shows a good impression of an *Engelhardtia* nut with the cast of the sepals and style.

Engelhardtia sp. 2

Plate VI, fig. 6.

Bract small, parallel-sided with entire margin. Nervation camptodromous, nerves prominent on the lower surface; median nerve conspicuous, secondary nerves opposite or alternate, arising from the midrib at angles of from 40° to 60° , sub-parallel to one another, nearly straight; tertiary nerves few, forming an elaborate series of loops with the median nerve and secondaries; surface beset with conspicuous discoid glands with radiating structure and filled with a resinous substance. Length incomplete; breadth 5 mm.

One imperfect impression of the lower surface.

The glands and nervation are strongly reminiscent of Juglandaceae. At first we supposed the specimen to represent a leaf or leaflet, but a comparison with living material showed it to be the bract of a fruit. Similar looped nervation is sometimes seen in the bract of *Engelhardtia spicata* and of other species, while some species, e.g. *E. nudiflora*, have discoid glands on the bract as well as on the nut.

Although the specimen is too fragmentary to name, its slender, small, parallel-sided form, and especially its nervation, exclude it from *E. macroptera*; we therefore leave it as *Engelhardtia* sp. It is much nearer than *E. macroptera* to the living representatives of the genus.

V.17571 Figured Pl. VI, fig. 6, is a fragment of the dorsal lobe of the bract.

Genus HOOLEYA nov.

DIAGNOSIS: Fruit inferior, flattened, with two large flat, thin, lateral wings; attachment basal; styles apical, two, stigmas four, surface with discoid glands.

GENOTYPE: *Hiraea Hermis* Unger.

Hooleya Hermis (Unger)

Plate VI, figs. 7-9.

- 1851 *Hiraea Hermis* Unger, *Denkschr. Ak. Wiss. Wien*, ii, p. 176, pl. I, figs. 11, 12.
- 1851 *Terminalia Fenzliana* Unger, *tom. cit.* p. 181, pl. liv, figs. 15, 16, 18.
- 1858 *Hiraea Hermis* Unger: Ettingshausen, *Sitzber. Ak. Wiss. Wien*, xxviii, p. 500.
- 1858 *Terminalia Fenzliana* Unger: Ettingshausen, *loc. cit.*

- 1874 *Hiraea Hermis* Unger : Schimper, *Traité Pal. Vég.* iii, p. 152, pl. xcix, fig. 14.
 1877 *Terminalia Fenzliana* Unger : Ettingshausen, *Denkschr. Ak. Wiss. Wien*, xxxvii, p. 203, pl. xix, fig. 17.

DIAGNOSIS : As for genus.

DESCRIPTION : Fruit inferior, with sub-pentagonal flattened nut ; perianth accrescent, produced laterally to form two large, rounded wings lying in the plane of the nut ; styles two, long and divergent, sunk between the lobes of the wings. At the apex, on either side of the styles, are the remains of the free perianth lobes which extend beyond the upper margin of the fruit. Stigmas four, slender ; base of nut broad, slightly concave, with ellipsoidal scar of attachment. Surface of nut with three or five longitudinal vascular bundles arranged symmetrically, branching above ; along the margin of the nut on either side a thick lateral bundle gives off nerves which radiate towards the margin of the wing, bifurcating about half-way and occasionally anastomosing ; fine sculpture a close network of hexagonal cells. The surface of the nut, and of the wings near the nut, is beset with discoid papillae (usually occurring as pits in the impressions). In one specimen (V.17989) the glandular papillae themselves are preserved and show the characteristic radiating striae, which are also seen in *Engelhardtia* and other Juglandaceae (cf. Pl. VI, figs. 4, 5). Length of fruit without styles 3·25 to 3·5 mm. ; length of style and stigmas 1·25 to 1·5 mm. ; breadth of fruit including wings 10 to 16·5 mm. ; breadth of nut alone 3 to 4 mm.

Impression, except for the glands in one specimen.

It is much to be regretted that the flattened form of the fruit makes it impossible to distinguish the locules even in the few specimens where parts of the pericarp are preserved.

AFFINITIES : At first sight, the form and wings suggest a gigantic fruit of *Betula* ; but certain characters exclude it, not only from the genus, but from any close relationship : (i) The occurrence of four stigmas. (ii) The nervation and cell-structure of the wings : in *Betula* there are no radiating nerves, but the wing is formed of inflated polygonal cells of fairly uniform character. (iii) The size : the fruits of *Hooleya* are much larger than in any known *Betula*. (iv) The presence of the discoid glands, which do not occur in *Betula*.

The inferior ovary debars comparison with any winged Urticaceae as does the character of the nervation.

The only family in which we have been able to find all the characters is Juglandaceae, and even in this family no one living genus shows them all. Pentagonal, flattened fruits with lateral wings, broad concave bases and two styles are seen in *Platycarya* ; but in this genus the fruit is smaller, the base more concave, the lateral wings narrower, forming a mere rim, the nervation and texture entirely different. Wings with similar nerves occur in

some species of *Pterocarya*, particularly in *P. hupehensis* Skan. *P. Forrestii* W. W. Smith, and *P. stenoptera* C.DC., have two wings like the fossil. Discoid hairs are characteristic of many Juglandaceae. We therefore regard the fossil as an extinct or unknown member of that family.

Judging by Unger's figures (1851, pl. 1, figs. 11, 12) there can be little doubt that the genus *Hooleya* is found at Sotzka, referred, under the name *Hiraea Hermis*, to a living genus of Malpighiaceae; but in this family the fruit is superior. In *Hiraea* itself the fruit is uncompressed and there is always a third wing more or less developed. Further, there are no glands on the fruit or wing. The Bembridge fossil cannot belong to *Hiraea* or to Malpighiaceae, and we have therefore given it a new generic name, *Hooleya*, in honour of the late R. W. Hooley, to whom the recovery of this fine collection is due.

Further, we think it possible that the specimen named *Terminalia Fenzliana* from Sotzka (Unger 1851), and some at least of those from Sagor (Ettingshausen 1877), may also be examples of *Hooleya* which have been distorted, although one style only is figured. In the Bembridge fossils, the styles cannot always be seen, and sometimes one only is visible, so that their apparent absence counts for very little.

- V.17015 Holotype: figured Pl. VI, fig. 7. Fruit with wings showing adherent calyx with sepals projecting at apex, and between them two styles; fruit and one wing almost complete.
- V.17014 Figured Pl. VI, fig. 8. Complete fruit showing bases of styles, also base of fruit; with counterpart.
- V.17572 Figured Pl. VI, fig. 9. Complete fruit with large portion of wings; showing nervation over fruit, base, and discoid glands dotted over fruit and part of wings.
- V.17988 Fruit with glands showing two stigmas on one of the styles (important specimen).
- V.17989 Fruit with organic discoid glands. (Important specimen.)
- V.17990-92 Three sets of counterparts showing fruits; V.17990 shows style; V.17991 shows entire margin to wing.
- V.17993 Almost complete fruit; shows style.
- V.17994 Almost complete fruit.
- V.17995-18006 Twelve specimens showing portions of fruit, wings, or both.
- V.18007-08 Two specimens (fragments), one with *Typha* fruit, the other with *Azolla* fruit on same block.

Family **BETULACEAE**Genus **CARPINUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 998.

Carpinus sp.

Plate VI, fig. 10.

DESCRIPTION : Nut inferior ; calyx accrescent to the apex and produced above into ligulate lobes which project much above the style ; asymmetric, broadly oval, broader than long, with numerous conspicuous, longitudinal ribs ; attachment basal, small, style apical. Involucre not preserved. Length including calyx lobes 6 mm. ; length without calyx lobes 5 mm. ; breadth 6 mm.

AFFINITIES : The shape and general dimensions of this nut correspond with *Carpinus*. Large specimens of *Carpinus betulus* Linn. sometimes agree with the fossil in size, shape, and asymmetry, also in the large number of ribs. The calyx, however, is not accrescent to the extreme apex, the calyx lobes are shorter, and the area of attachment is much larger. In these respects certain Oriental species more nearly resemble the fossil ; thus small areas of attachment occur in *C. laxiflora* Blume and *C. Turczaninovii* Hance. The latter species has long projecting calyx lobes also.

We know no fossil *Carpinus* with nut closely resembling the Bembridge specimen. The nearest seems to be *Carpinus* sp. from the Mio-Pliocene of Pont-de-Gail (E. M. Reid 1920b, p. 63, pl. iii, fig. 17). This species also is related to *C. betulus*, but it is rather poorly preserved, and does not show any free calyx lobes ; also it has fewer ribs and a larger area of attachment than the Bembridge fossil.

V.17573 Figured Pl. VI, fig. 10. Nut with perianth and perianth segments at apex.

Family **FAGACEAE**Genus **FAGUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 997.

Fagus sp. ?

Plate VI, fig. 11.

Leaf, large, oval, with long petiole ; extreme apex broken ; margin entire but undulate ; nervation craspedodromous, prominent on the lower surface, strong, continued to the apex ; secondary nerves opposite or sub-opposite, arising from the midrib at angles of about 48° and running straight and sub-parallel

to one another. It is possible to make out a short backward-directed nerve given off by the upper secondaries near the margin, but the rest of the nervation is too obscure for description. The specimen, if the two parts belong (see below), is broken and in a bad state of preservation; it is impossible to determine the texture of the leaf or character of the surface. Impression. Length imperfect; breadth 34 mm. approx.

The form and type of nervation suggest a species of *Fagus*.

V.17574 Figured Pl. VI, fig. 11, shows the lower surface. The specimen is broken across the middle, and although it is no longer possible to fit the two fragments closely together, they almost certainly are parts of the same specimen. They are preserved in the same soft white matrix, they correspond in size, in direction and character of nervation and in state of preservation. The specimen must have been a fine one when it was first collected, but subsequent neglect has caused it to decay.

Genus **QUERCUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 994.

Quercus sp. ?

Plate VI, fig. 12.

Nut ovoid, broader than long, faintly ribbed longitudinally; base broken, but enough remains to show an encircling line along which, to right and left, the base has broken away; surface of small, square, inflated cells in longitudinal rows which radiate from the apex. Length (from apex to broken base) 5 mm.; breadth 7 mm. Impression.

The form and character of the impression suggest a nut with a large differentiated area of attachment such as is found in *Corylus*, *Castanea*, *Quercus*, and *Hippocastanum*. A comparison with these genera showed that the cell structure of the surface was at variance with all but the nuts of *Quercus*.

V.17575 Figured Pl. VI, fig. 12, is an external impression of one side of a nut with base broken away.

Family **URTICACEAE**

Genus **FICUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 1059.

Ficus sp.

Plate VI, figs. 13, 14; text-fig. 6.

DESCRIPTION: Leaf oval, apex broken, base gradually narrowed into the petiole; petiole thick and fairly long, with

marked transverse rugosities, terminating at the blade in a conical end; margin entire, thickened; texture of blade coriaceous. Nerves prominent on both surfaces, midrib thick, flanked by two strong lateral nerves which arise from the base and run close to, and parallel with, the margin for about half the length of the leaf, then, curving in, they unite with the first pair of secondary nerves; secondary nerves few and far apart (lowest 15 mm. from the base), given off from the midrib at angles varying from 58° to 62° , concave upwards, uniting to form large loops with roundly-flattened outer portions near, and sub-parallel to, the margin; the secondary loops are connected on the outer side by subsidiary loops, also sub-parallel to the margin; tertiary nerves from midrib

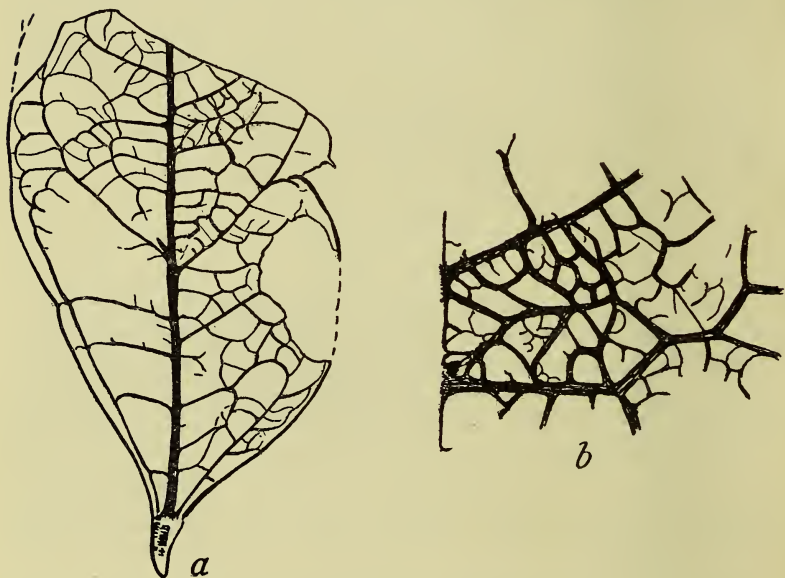


FIG. 6.—*Ficus* sp. *a*, Outline drawing to show nervation, $\times 1.5$. *b*, Outline drawing of a portion of the leaf, on the right of the midrib near the apex; more highly magnified to show details of nervation, $\times$ about 4. Both are camera lucida drawings from V.17576.

and secondaries well defined, given off at wide angles; nerves connecting the midrib and basi-laterals arising at right angles from the midrib on the left and at acute angles on the right; ultimate network rather coarse. Length (imperfect) 47 mm. excluding stalk; breadth at least 30 mm. Impressions (counterparts).

DISCUSSION: The large rock fragment is labelled *Ficus* in pencil, and Gardner states (1888, p. 419) that a specimen of *Ficus* was determined during his visit with Saporta to view A'Court

Smith's collection. This is probably the specimen, for it came in a tray with a faded label "Fossil leaves named by the Marquis de Saporta and J. S. Gardner, Esq., F.G.S.", and shows the general character of the genus *Ficus*.

After a study of living material we reached the conclusion that the following are the most distinctive specific characters of the fossil: (i) the smooth coriaceous texture; (ii) the three strong nerves arising from the base; (iii) the nearness of the basi-lateral nerves to the margin; (iv) the wide spacing of the secondaries; (v) the relatively acute angles at which the secondaries meet the midrib; (vi) the relative strength and conspicuousness of the tertiary nerves; (vii) the entire, thickened margin; (viii) the thick pedicel with transverse rugosities terminating at the blade in a conical end; (ix) the somewhat oblique upward direction of some of the marginal tertiaries (those on the right).

Among named living species, that which shows most of these characters, and bears the closest resemblance to the fossil is *F. gibbosa* Blume. The last character only, the direction of the marginal tertiaries, is not found. But among unnamed specimens, one collected by C. Schneider from Yunnan (No. 271, Schneider, Kew Herb.) shows leaves extremely close. The leaf characters of this specimen suggest that it, too, in all probability, belongs to *F. gibbosa*. This species grows in Tropical Asia and Malaya, and there are specimens in Kew Herbarium from 1000 feet in Kumaon, 2500 feet in the Sikkim Himalaya, and from Yunnan. *F. parietalis* Blume is also somewhat like the fossil, but larger, and the basi-lateral nerves are too far from the margin. The marginal tertiaries, however, are directed upwards, as in the fossil, instead of arising at angles of 90°.

Of fossil species *F. Urani* Ettingshausen (1867, pl. xxi, fig. 5, p. 151) from Bilin has similar nervation but no transverse striations on the stalk.

In the absence of the complete leaf we have given no specific name.

V.17576 Two counterparts, figured Pl. VI, figs. 13, 14, and text-figure 6. The large block is the impression of the lower surface, the small that of a fragment of the upper.

Family NYMPHAEACEAE

Genus **BRASENIA** Schreber

1789 Gen. Pl., I, p. 372.

Brasenia ovula (Brongniart)

Plate VI, figs. 15-18.

1822 *Carpolithes ovulum* Ad. Brongniart, in Cuvier & Al. Brongniart, Descr. Géol. Env. Paris, p. 366, pl. xi, fig. 6.

- 1855 *Carpolithes ovulum* Brongniart : Hooker, *Q.J. Geol. Soc.*, xi, p. 562, pl. xvi.
 1862 *Carpolithes ovulum* Brongniart : Bristow, Geol. Isle of Wight, p. 122.
 1862 *Nymphaea Doris* Heer, *Q. J. Geol. Soc.*, xviii, p. 374, pl. xviii, figs 8-11.
 1862 *Carpolithes globulus* Heer, *loc. cit.* p. 375, pl. xviii, figs. 14-16.
 1862 *Nymphaea Doris* Heer, *Phil. Trans. R. Soc.*, clii, p. 1072, pl. lxx, figs. 32-37.
 1888 *Carpolithes globulus* Heer : Gardner, *Rep. Brit. Assoc.* (1887), p. 421, pl. iii, figs. 1-10.
 1925 *Brasenia* sp. (*B. ovulum* Brongn. ?) : Chandler, Upper Eoc. Flora, p. 23, pl. iii, figs. 7a-7d.

DIAGNOSIS : Seeds globular or ovoid, very variable in size, black and shining ; testa thick, brittle, smooth, formed of digitate cells.

DESCRIPTION : Seeds very variable in form and size, ovoid to globular ; aperture for the embryotega small, circular ; testa thick, brittle, of columnar cells, external surface smooth and shining, often with obscure longitudinal ridges radiating from the embryotega ; surface cells with interlocking digitations ; an inner semi-transparent coat may represent a perisperm layer or a second seed coat. Germination by the extrusion of the embryotega, which is small, conical or convex above, with a prominent asymmetric, rimmed micropyle ; surface cells of embryotega large and oblong. Length 1.1 to 5.5 mm. Actual seeds, especially in a soft white matrix, also internal casts and external impressions.

DISCUSSION : The species is identical with that found in such profusion in the Lower Headon Beds of Hordle (Chandler, 1925) ; it is equally abundant in the Bembridge marls, large blocks more than 70 mm. thick being formed almost entirely of the seeds (Pl. VI, fig. 15). We have been unable to find any distinction, except size, between the largest and smallest specimens, and the extreme sizes are connected through countless intermediates. Original differences in size may, moreover, have been accentuated by differential shrinkage depending on the matrices and conditions of preservation. That great shrinkage has undoubtedly occurred is obvious, for frequently the actual seeds lie loose within the impressions of the external surface, to which they must once have adhered closely, and in this way a decrease in diameter amounting to 33 per cent. has sometimes been measured.

The species, which seems to be the same as *B. ovula* (Brongniart), has been recorded from the Eocene of the Paris Basin, Lewisham (Kent), Hordle (Hampshire), and the Isle of Wight ; also from the Oligocene of Bovey Tracey (Devon) and Hamstead (Isle of Wight). As stated elsewhere (Chandler, 1925, p. 24), the specific name, which has evidently been used for identical or closely allied species, is at least a useful group name to connote smooth-walled *Brasenias* of this type.

- V.17577 Figured Pl. VI, fig. 15. Mass of *Brasenia* seeds in matrix (impressions and casts).
 V.17578 Figured Pl. VI, fig. 16. Seed (perfect), obtained by washing.
 V.17579 Figured Pl. VI, fig. 17. Internal cast of seed cavity with cast of germination opening.
 V.17580 Seed figured Pl. VI, fig. 18, for cell-structure ; obtained by washing.
 V.18009-11 Specimens (in tubes) from soft marl ; released with many Charas, some nuts of *Potamogeton* and *Limnocarpus*, also seed of *Papaver*, by washing.
 V.18012-17 Lumps of matrix full of *Brasenia*.
 V.17032-33 Blocks with well-preserved casts.
 V.14747 Mass of seeds in matrix. East end of Thorness Bay. *Collected and presented by Prof. T. D. A. Cockerell, 1920.*
 Many blocks full of *Brasenia* were not catalogued.

Family RANUNCULACEAE

Genus CLEMATIS Linnaeus

1753 Spec. Pl., ed. 1, p. 543.

Clematis vectensis n. sp.

Plate VI, figs 31-33.

DIAGNOSIS : Achenes oval, somewhat narrowed below, nearly flat in section, glabrous and slightly rugose, with very long awn, not stipitate, with well-developed rim and lateral bundles.

HOLOTYPE : V.17583.

DESCRIPTION : Achene sub-oval, flat, sessile or occasionally sub-stipitate, with a well-defined rim, tapering gradually into the long awn ; surface showing over the rim large square cells aligned in rows, and striate over the middle with small cells aligned longitudinally. A cylindrical vascular strand enters at the base and immediately bifurcates, a branch passing up within the rim on each side ; at the apex the branches re-unite and enter the awn ; at the apex of the locule one of the bundles gives off a short downward-directed branch to the placenta of the seed.

Seed flat, pendulous, albuminous, endosperm enclosed by a delicate hyaline membrane formed of quadrilateral cells.

Length of longest fruit, including awn, 19 mm. ; length of fruit, excluding awn, 3.5 to 6 mm. ; breadth 1.6 to 3 mm.

External impressions sometimes with the remains of actual carpels lying within them : endosperm replaced by a cream-coloured granular substance (see p. 7).

There are numerous specimens all representing one species, for although certain minor differences in size and shape can be observed, a comparison with living material shows that these are not of specific value. No hairs are preserved. Their absence may denote a specific character, or may be due to maceration which causes them easily to rub off.

AFFINITIES: We compared the fossils with *Anemone* and *Geum*, but in neither genus do the fruits agree with the fossil species; and in the latter the seeds are erect, not pendulous.

Our study of living *Clematis* shows that the chief specific characters in the fruits may be grouped as follows :

- (i) Outline varying from circular to elongate-oval ;
- (ii) Cross-section varying from flat or dumb-bell shaped to nearly terete ;
- (iii) Surface hairy, pubescent or glabrous ;
- (iv) Rugosity of the surface ;
- (v) Length and character of the awn ;
- (vi) Degree of stipitation ;
- (vii) Degree of development of rim and lateral bundles ;
- (viii) Cell-structure.

The characters of the fossil place it among species which are (i) oval and somewhat narrowed below, (ii) nearly flat in section, (iii) glabrous or nearly so, (iv) but slightly rugose, (v) with very long awn, (vi) not stipitate, (vii) with well-developed rim and lateral bundles, (viii) with cell-structure as described above. This combination of characters limits its resemblance to comparatively few species in this large genus. The most like it are *C. heracleafolia* DC. (= *C. tuberosa* Turcz.), a Chinese species, and *C. lasiantha* Nutt. from North America. The former species is almost identical in size and shape, but the square cells of the rim are less conspicuous ; the latter shows conspicuous rim-cells.

Clematis fruits have been recorded fossil by Heer, who names and figures three species, but his figures and descriptions are inadequate for more than generic determination (Heer, 1859, iii, p. 29, pl. cviii, figs. 1-4). A specimen has also been figured from Célas, by Professor Laurent, who gives a generic description. His figure (Laurent, 1899, pl. xii, fig. 8) suggests that the Célas fossil may perhaps be comparable with *C. vectensis*. This specimen agrees in size and in general form, but is rather more pointed at the base and apex. Another specimen (pl. xii, fig. 9) is smaller. Closer comparison is impossible because no details of structure are described or figured.

V.17583 Holotype ; figured Pl. VI, fig. 31. Fruit (impression) complete with awn, with a corona of iron staining. Counterpart shows basal bundle.

V.17584 Figured Pl. VI, fig. 32. Fruit with long awn (impression).

V.17585 Figured Pl. VI, fig. 33. Impression of fruit without awn, but with some remains of organic matter ; shows ribs, rim, and cell-structure.

V.18019 Fruit (impression) with incomplete cast of interior.

V.18020 Fruit with remains of organic matter and granular endosperm.

V.18021 Fruit with style, showing impression of surface cells and remains of organic matter including vascular bundles in style ; with counterpart.

- V.18022 Fruit with broken style, showing basal bundle ; with counter-part.
 V.18023 Fruit showing organic remains of lateral bundle.
 V.18024-25 Two fruits showing long styles. *Azolla* on both blocks.
 V.18026-38 Thirteen very good specimens, some with styles and some with remains of organic substance.
 V.18039-41 Three specimens (with *Azolla* on same blocks).
 V.18042 Good specimen with long awn. *Hooleya* showing glands on same block.
 V.18043-47 Five specimens with counterparts.
 V.17051 Impression of fruit.
 V.18083 On block with *Abelia quadrialata*, see p. 134.

Genus **RANUNCULUS** Linnaeus

1753 Spec. Pl., ed. 1, p. 584.

Ranunculus heterostylus n. sp.

Plate VII, figs. 1-4.

DIAGNOSIS : Achene very small, sub-ovate to semi-lunar, flat ; style apical on the ventral margin, very long and slender, either continuous with the ventral margin, or at right angles to it or in any intermediate position ; walls pitted and rugose externally, moderately thick, with corky (?) cells on the ventral and apical margins.

HOLOTYPE : V.17587.

DESCRIPTION : Achene one-seeded, very small, sub-obovate to semi-lunar, laterally flattened, splitting on germination into symmetrical halves through style and attachment. Style apical on the ventral margin, conical at the base, but tapering above into a long slender beak, as long as, or longer than, the width of the achene, directed either upward in a line with the ventral margin, forward at right angles to it, or along any line in the plane of the fruit between these two. Attachment basi-ventral. Walls pitted externally, moderately thick, formed of three layers ; external layer of loose cells forming a thick corky apical and ventral margin ; middle-layer thin but hard and woody formed of irregular, longitudinal fibres which give rise externally to marked rugosities and which form a strong rim continued into the style ; inner layer thin, formed of fine, close-set, glistening fibres, transverse in general direction, especially over the middle of the locule, but towards the edge having the appearance of a finger-print. Length 1 to 2 mm. (excluding style) ; breadth 1 to 1.4 mm. ; longest style 1.5 mm. External impressions, a few internal casts and rare carbonaceous endocarps, or fragments of them.

Seed albuminous, testa thin-walled formed of square, or polygonal cells ; endosperm represented as in *Clematis* (p. 101) by a cream-coloured granular substance. Seeds represented by remains of the testa usually adhering to the carpel walls.

AFFINITIES : There is no doubt that this fossil is a species of *Ranunculus*, as all its characters are found in this genus. Its most distinctive features are (i) the combination of long style, flat seed, and small size, (ii) the longitudinal rugosities so conspicuous externally, (iii) the variation in direction of the long slender style. This third character is very rare in European species. A somewhat similar style occurs in *R. Purshii* Richards, from North Russia and North America, *R. thasius* Hal. from the Isle of Thasos, and *R. Wilkommianus* from Spain, but otherwise none of these achenes agree with the fossil. The character of style is common in species from New Zealand. The nearest we have seen are *R. crassipes* Hooker, in which the style is shorter in proportion to the size of achene and *R. rivularis* D.C. The latter species has achenes which are similar in size, shape, and character of style.

From observations of recent material we learn that great variability in the direction of the style only occurs in species in which the fruiting heads have all their styles parallel to one another and upwardly directed. In such heads the upper achenes have styles aligned with their ventral margins, and the basal ones have them at right angles to these ; between the top and base they follow intermediate directions. We may therefore conclude that such was the form of the fruiting head of *Ranunculus heterostylus*.

It is probable, judging from the number of achenes preserved, that the species was an aquatic or marsh plant.

Heer figures a *Ranunculus* (*R. emendatus*) from Oeningen, but his description is very slight and his figures are inadequate ; they apparently show a symmetric achene, with an apical style, and a smooth surface (Heer, 1859, iii, p. 29, pl. cviii, fig. 5). We cannot therefore refer the Bembridge species to *R. emendatus* Heer.

V.17587 Holotype : figured Pl. VII, fig. 2. Impression of achene.

V.17586 Figured Pl. VII, fig. 1. Endocarp freed from matrix showing cell structure and remains of endosperm (mostly lost now).

V.17588 Figured Pl. VII, fig. 3. Impression of achene.

V.17013 Figured Pl. VII, fig. 4. Impression (with counterpart) of endocarp with part of seed in place, showing cell-structure.

V.17028 Cast of endocarp and also specimen showing seed coat.

V.17048 Cast of endocarp.

V.18048 Impression with remains of achene showing cells of interior.

V.18049 Block and counterpart with three impressions, two of which show internal casts with endosperm.

V.18050-57 Eight blocks showing impressions of achenes.

V.18058-61 Four blocks showing internal casts associated with impressions of achenes.

V.18062 Impression of achene ; with impressions of three specimens of *Potamogeton* on same block.

V.17503 See under *Azolla*, p. 43.

Family LAURACEAE

Genus CINNAMOMUM Blume

1825 Bijdr. Fl. Nederl. Ind., p. 568.

Cinnamomum lanceolatum (Unger)

Plate VII, figs. 5-8, text-fig. 7.

- 1851 *Daphnogene lanceolata* Unger, *Denkschr. Ak. Wiss. Wien*, ii, p. 167, pl. xxxvii, figs. 1-6.
- 1854 *Daphnogene lanceolata* Unger : Ettingshausen, *Denkschr. Ak. Wiss. Wien*, viii, p. 31, pl. vii, fig. 7.
- 1856 *Cinnamomum lanceolatum* (Unger) : Heer, *Flora Tert. Helv.*, ii, p. 86, pl. xciii, figs. 6-11.
- 1862 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (4) xvii, p. 242.
- 1862 *Cinnamomum lanceolatum* (Unger) : Heer, *Phil. Trans. R. Soc.*, clii, p. 1063, pl. lxvii, figs. 1-8, pl. lxviii, figs. 14, 15.
- 1865 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (5) iii, p. 94.
- 1865 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (5) iv, p. 133.
- 1867 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (5) viii, p. 83.
- 1868 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (5) ix, p. 40, pl. iv, figs. 11-16.
- 1870 *Cinnamomum lanceolatum* (Unger) : Engelhardt, *Flora Braunkohlenform. Sachsen*, p. 20, pl. iv, figs. 11-12.
- 1873 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (5) xviii, p. 44, pl. viii, fig. 10.
- 1888 *Cinnamomum lanceolatum* (Unger) : Saporta, *Orig. pal. arbres*, p. 227, fig. 28¹.
- 1889 *Cinnamomum lanceolatum* (Unger) : Saporta, *Ann. Sci. Nat., Bot.* (7) x, p. 31, pl. vi, figs. 5-10.
- 1922 *Cinnamomum lanceolatum* (Unger) : Menzel, *Jahrb. Preuss. Geol. Landesanst.* xli, p. 367, pl. xv, fig. 32.

DIAGNOSIS : Leaf lanceolate, with thickened margin ; nervation acrodromous, midrib strong, two alternate lateral nerves given off some distance above the base.

DESCRIPTION : Leaf lanceolate (broken at base and apex), with a thickened entire margin ; midrib strong, two strong lateral nerves arise alternately from the midrib some way above the base and run sub-parallel to the margin ; secondary nerves are given off from the midrib at some distance from the laterals, they emerge at acute angles, and unite with the laterals to form loops ; two delicate nerves at the extreme margin spring from the base and ultimately form a series of flat loops with the marginal tertiaries ; tertiary nerves are given off at right angles from all the above-mentioned nerves, and connect them, sometimes branching and

anastomosing among themselves; very short tertiaries are also given off, at right angles, from the delicate marginal nerves and connect these with the margin; quaternary nerves arise from the tertiaries at right angles and ultimately form a close network. All the nerves are prominent on the lower face, sunk on the upper. Length incomplete; breadth 8 mm.

The lower portions of two other leaves are also preserved; one shows the base narrowing into a long slender petiole (fig. 6), broader below than above. Despite their imperfect condition they show many of the characters of *C. lanceolatum* and must be



FIG. 7.—*Cinnamomum lanceolatum* (Unger). Camera lucida drawing of specimen V.17589 to show details of nervation, $\times$ nearly 3.

associated with the more perfect leaf just described. Small cuticle preparations (figs. 7, 8) were made from the specimen in fig. 6.

Cuticle of upper surface of thick-walled polygonal cells with slightly tortuous cell-walls, not sinuous as is commonly the case in *Cinnamomum*. Cells over the nerves oblong. Cuticle of lower surface thickly beset with circular hair-bases; each hair-base is surrounded by six or seven oblong cells radially arranged. Stomata fairly numerous, sunk, approximately circular, very obscure, but with narrow apertures and wide guard-cells, surrounded by about five to seven epidermal cells.

The resemblance between this leaf and *C. pedunculatum* Nees var. *angustifolium* Hemsley is very close, as can be seen if figs. 5 and 9 be compared. Some time after we had reached this conclusion, Mr. P. Marty drew our attention to the fact that Saporta (1888, p. 227, 1889, p. 31) had also been greatly impressed by this similarity. He says: "Le *C. lanceolatum* . . . se rattache directement à une espèce chinoise actuelle, recueillie récemment par le docteur Henry (févr. 1887) et désignée par lui sous le nom de *Cinnamomum pedunculatum* Nees var. *angustifolium*." This species is recorded from Western China and Yunnan. In common with *C. brevifolium* and *C. Wilsonii*, it shows cuticle with cells like those of the fossil. The lower surface of *C. brevifolium* is thickly beset with hairs which leave circular scars surrounded by six or seven cells as in *C. lanceolatum*. Many species of *Cinnamomum* show similar sunk stomata, with wide, thin-walled guard-cells, and slit-like apertures.

C. lanceolatum has frequently been recorded from the Tertiary of Europe.

- V.17589 Figured Pl. VII, fig. 5. Impression of lower surface of leaf, with upper surface on counterpart.
 V.17590 Figured Pl. VII, figs. 6-8. Base of leaf with long petiole showing organic remains from which cuticle was obtained (figs. 7, 8).
 V.18063 Doubtful specimen, not figured.

Cinnamomum Scheuchzeri Heer

Plate VII, figs. 10-12; text-fig. 8.

- 1856 *Cinnamomum Scheuchzeri* Heer, Flora Tert. Helvet., ii, p. 85, pl. xci, figs. 4-24; pl. xcii, pl. xciii, figs. 1, 5.
 1860 *Cinnamomum Scheuchzeri* Heer: Gaudin & Strozzi, *N. Denkschr. Schweiz. Naturf. Ges.*, xviii, 4, p. 49, pl. viii, figs. 5, 7.
 1867 *Cinnamomum polymorphum* Heer: Saporta, *Ann. Sci. Nat., Bot.* (5) viii, p. 83, pl. viii, fig. 1.
 1888 *Cinnamomum Scheuchzeri* Heer: Saporta, *Orig. pal. arbres*, p. 227, fig. 28² [=fig. 1 of 1867, above].
 1889 *Cinnamomum Scheuchzeri* Heer: Saporta, *Ann. Sci. Nat., Bot.* (7) x, p. 33, pl. v, fig. 6, pl. vi, fig. 1.
 1922 *Cinnamomum Scheuchzeri* Heer: Menzel, *Jahrb. Preuss. Geol. Landesanst.*, xli. p. 367, pl. xv, Figs. 33, 34.

DIAGNOSIS: Leaf oval; nervation acrodromous, lateral nerves supra-basal, sub-parallel with the margin, uniting with the secondary nerves near the apex.

DESCRIPTION: Leaf oval (extreme base and apex broken), equally narrowed above and below, margin entire and thickened; three-nerved, all nerves sunk on the upper surface, lateral nerves supra-basal, acrodromous, making a curve concave upwards at their bases, and running sub-parallel with the margin, uniting with the secondary nerves near the apex; secondary nerves given off from the midrib in the upper part only, at rather wide angles; tertiary nerves more or less at right angles to the primaries and secondaries. Cuticle of the upper surface of fairly large polygonal cells with slightly tortuous, but not sinuous, outlines, and with oblong cells over the nerves; cuticle of the lower surface (only a minute fragment obtained) of larger and more irregular polygonal cells than those of the upper surface and with more tortuous outlines (fig. 12). Occasional scars of hair bases are scattered over the thickened margin (fig. 11). No stomata seen. Length of leaf imperfect; breadth 33 mm.

DISCUSSION: One badly preserved impression shows the upper surface of a leaf with minute fragments of organic substance. It was only possible to make very small cuticle preparations, but unfortunately it was almost entirely cuticle from the

thick margin that was obtained, a few cells only of the lamina remaining. So far as can be seen the structure is in agreement with species of *Cinnamomum*, and we have observed hair-bases similar to those of the fossil in *C. brevifolium* Miq. among living species. The cells are larger and the cell-walls thinner and more tortuous than those of *C. lanceolatum*.

When compared with fossil species, the specimen is found to agree very closely with *C. Scheuchzeri* Heer, in which the form



FIG. 8.—*Cinnamomum Scheuchzeri* Heer. Camera lucida drawing of specimen V.17591 to show nervation. Natural size.

is similar, and the lateral nerves run sub-parallel with the margin until they anastomose with the secondaries near the apex. It was labelled *C. Rossmässleri* Heer on an old faded label, but it cannot belong to that species, which is characterised by lateral nerves that reach to the apex of the leaf. Neither can it be referred to *C. polymorphum* Heer, although Gardner recorded it under that name (Gardner, 1888, p. 419, Bristow, 1889, p. 183), for in *C. polymorphum* the lateral nerves are not parallel with the margin, nor do they extend so far along the blade as in the Bembridge impression.

V.17591 With slides *a* and *b*. Figured Pl. VII, figs. 10–12; text-fig. 8. Impression of upper surface of leaf with fragmentary organic remains of lamina from which scraps of cuticle were obtained (figs. 11, 12).

Genus **NEOLITSEA** Bentham

1880 Bentham & Hooker, Gen. Pl., III, p. 161.

1906 Merrill, Philipp. Journ. Sci., I, suppl., p. 56.

Neolitsea sp.

Plate VII, figs. 13-16; text-fig. 9.

DESCRIPTION: Leaf oval (base and apex broken), very thick and leathery; midrib conspicuous, nerves immersed in the substance of the lamina and scarcely visible on either surface, but faintly prominent on the lower and sunk on the upper; lateral nerves running about half the length of the leaf, then anastomosing with the secondaries; secondary nerves sub-opposite, emerging from the midrib at angles of 30° to 40° (five pairs and one odd nerve visible); tertiary nerves (only seen on the laterals) given off at angles of 90° ; finer nervules, forming enclosed quadrilateral spaces with no free endings, very numerous and broad (about

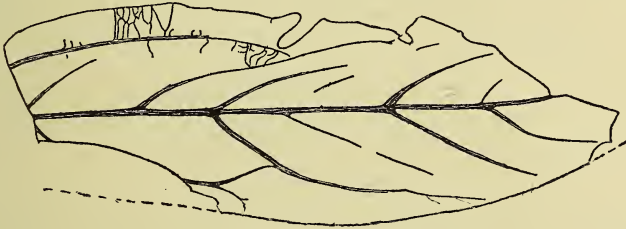


FIG. 9.—*Neolitsea* sp. Camera lucida drawing to show nervation. Specimen V.17592, $\times$ nearly 2.

four or five cells wide). Cuticle of upper surface formed of small polygonal cells (fig. 16), that of lower surface of larger polygonal cells with their walls slightly bowed between the angles; stomata fairly abundant, variously oriented, usually surrounded by four or five cells; guard-cells broad, much thickened on their inner margins (figs. 14, 15).

Length of leaf imperfect; breadth 16 mm.

An impression of the lower surface with much of the actual leaf showing the upper surface.

This leaf is labelled "*Oreodaphne*" in pencil on the stone, we do not know by whom, and there is no published record of its determination. We compared it macro- and microscopically with representatives of various families and genera which showed a similar nervation, but it agreed only with Lauraceae. The comparable genera in that family were *Neolitsea*, *Oreodaphne*, *Cinnamomum*, and *Lindera*. The last two named are excluded by their cuticular structure. *Oreodaphne foetens* Nees has fewer, usually alternate, secondary nerves given off at wider angles,

whilst in the angles between the midrib and lowest secondaries there are tufts of hairs such as have not been seen in the Bembridge impression. Moreover, the tertiary nerves of *Oreodaphne* are fewer and more prominent, the cuticular cells on both surfaces are much larger and have thinner and more sinuous walls, the ultimate network of fibres is much coarser and of narrower strands, only three cells wide. *Neolitsea cinnamomea* and *N. umbrosa* resemble the fossil both as regards nervation and cuticular structure. The ultimate meshes of fibres in both species are identical in character, the strands being four or five cells wide. The cuticles of both surfaces are of similar polygonal cells, and the stomata and guard cells are comparable in character. We therefore regard the fossil as a *Neolitsea*, not as *Oreodaphne*, but on account of its imperfect form we have given no specific name.

The living genus *Neolitsea* is found in the Himalayas, Japan, China, Formosa, India, Further India and the Malay Peninsula.

V.17592 With slides *a* and *b*. Figured Pl. VII, figs. 13-16. Portion of leaf with a considerable amount of the organic matter of the lamina remaining, from which cuticle was obtained (figs. 14-16).

Family CRUCIFERAE ?

Genus ? (Valve of Fruit)

Plate VII, fig. 17.

Valve of fruit pointed-oval, thin, slightly convex externally, concave internally, with two strong lateral ribs forming a rim; nerves arising at the base and along the margins, anastomosing with one another to form a coarse network; surface showing vesicular, quadrangular cells which appear on the impression as rows of quadrangular pits. Length 11 mm.; breadth 4 mm. One impression.

In form and nervation the fossil somewhat resembles the valves of Crucifer pods such as *Alyssum*, certain species of *Draba* and so forth. The fruits of *Alyssum* are smaller, and in both genera the base is more rounded than either end of the fossil. We mention the resemblance but feel doubtful whether the specimen really belongs to the family.

V.17593 Figured Pl. VII, fig. 17, perhaps shows the external impression of the valve of a fruit.

Family **PAPAVERACEAE**Genus **PAPAVER** Linnaeus

1753 Spec. Pl., ed. 1, p. 506.

Papaver pictum n. sp.

Plate VII, figs. 18, 19.

DIAGNOSIS: Seed reniform, anatropous; surface ornamented with large contiguous, quadrilateral, shallow pits, having thin sinuous walls; pits aligned longitudinally over the dorsal surface, and transversely over the ventral.

HOLOTYPE: V.17594.

DESCRIPTION: Seed reniform, anatropous with a hilum and a short linear raphe on the ventral side; surface ornamented with large contiguous, flat-bottomed, shallow pits, sub-quadrilateral in outline and with sinuous walls which form a conspicuous network; the pits are aligned longitudinally over the convex dorsal surface, transversely on the concave ventral surface near the hilum, and they narrow and converge at the ends of the two limbs of the seed. Length 0.75 mm.; breadth 0.5 mm. Actual seed.

REMARKS: This beautiful little seed, which is perfect, was obtained by washing a few fragments of soft white marl. If any other organic remains were present they were destroyed in the process, with the exception of *Chara* fruits and *Brasenia* seeds.

The seed obviously belongs to Papaveraceae; we compared it with all genera of that family and there can be no doubt that it is a seed of *Papaver* itself. It is very similar to *P. rupifragum* Boiss. & Reut., a species which grows in Spain and Morocco, but is rather smaller. All other seeds of *Papaver* with which we were able to make comparison were either less curved or more coarsely and regularly pitted, and the walls of the pits had either more sinuous, or straighter, outlines.

V.17594 Holotype, figured Pl. VII, figs. 18, 19. Seed (organic).

Family **DROSERACEAE**Genus **ALDROVANDA** (Monti) Linnaeus

1747 Monti, Comment. Bonon. Acad., II, 3, p. 404.

1753 Linnaeus, Spec. Pl., ed. 1, p. 287.

DIAGNOSIS of seed characters: Seed urceolate, anatropous, black, shining; testa showing two distinct coats; the inner consisting of a single layer of long prismatic cells arranged radially; the outer consisting of a series of small radially arranged cells whose inflated ends form low tubercles on the exterior; raphe lying between the two coats, showing as a more or less marked ridge on the exterior and ending in a prominence at the chalaza.

For our recognition of this genus in a fossil state, we are indebted to Professor W. S. Dokturowsky, of Moscow. About three years ago he sent us for determination material of Pleistocene (Interglacial) age from Galitsch, near Moscow. In this we recognised a species which appeared to be identical with one previously figured by Dr. N. Hartz (1909, p. 173, pl. ix, fig. 14) from the Amber-Pine beds of Denmark, and determined by him as *Hydrocharis morsus-ranae* Linnaeus. Through the courtesy of the Danish Geological Survey we received specimens both of the Danish Interglacial species and of the living *Hydrocharis morsus-ranae*. These showed that the Galitsch and Danish fossils were identical, and that they were not *Hydrocharis*.

Meantime we had recognised the same genus among the Bembridge seeds, and had further realised that *Nuphar ovatum* Chandler (1925, p. 22, pl. iii, figs. 3a, b) must also belong to it.

On our notifying Prof. Dokturowsky that we proposed to refer the material to a new genus, he replied that he was convinced that the Galitsch seeds belonged to *Aldrovanda vesiculosa* Linnaeus. Although unable to obtain living material for comparison, he was led to this conclusion by Mr. P. A. Nikitin's description of *A. vesiculosa* seeds, and the admirable drawings by S. Korzhinsky (1887, pl. i). We were fortunately able to confirm Prof. Dokturowsky's determination by reference to living material kindly furnished by the Kew authorities.

The seed structure of *A. vesiculosa* is clearly illustrated in our figures of the Galitsch and Danish specimens (Pl. VI, figs. 19-23).

The present distribution of *Aldrovanda*, a monotypic genus, is most peculiar. It occurs, according to Engler, in Bengal, Queensland, the south of France, the north of Italy, Silesia, Lithuania, and near Cracow. Such a distribution, however, is in full harmony with its fossil history as now revealed. The late occurrence of *A. vesiculosa* in Interglacial beds of Denmark and Russia, shows that the species had formerly a more extended distribution in Europe than it has now, and that it must have escaped complete extermination in this part of the world by some fortunate chance. The early occurrence of the genus in strata of Eocene and Oligocene age is, again, in harmony with a distribution into such Eastern regions as Bengal and Queensland.

We may compare the fossil history and present distribution of *Aldrovanda* with those of *Brasenia* and *Dulichium*, both monotypic genera of water-plants which have been found in beds of Interglacial age in various parts of Northern Europe, and have, as well, a fossil history in the Tertiary. Unlike *Aldrovanda* both these genera suffered complete extermination in Europe during the later glaciation. *Brasenia* is now a cosmopolitan plant exclusive of Europe; *Dulichium* survives only on the continent of North America, where, however, it has a wide range.

Aldrovanda intermedia n. sp.

Plate VI, figs. 27-29.

DIAGNOSIS: Neck about one-tenth of the total length of the seed; raphe conspicuous and ending in a point over the chalaza; inflated ends of the testa cells but slightly raised; combined thickness of the two coats about one-fifth of the diameter of the seed. Average size 1.5 mm. $\times$ 1.2 mm.

DESCRIPTION: The seeds of the Bembridge species only differ from those of the living species in their greater size, more marked neck and raphe, less conspicuously tubercled surface and the greater thickness of the two coats of the testa. In both species the outer of these coats is black and formed of a series of small cells aligned accurately in radial directions. The inner coat is formed of a single layer of large prismatic cells, which show in section as columnar cells. These are brown, thin-walled and translucent. In all species the raphe lies between the two coats. Length 1.5 mm.; breadth 1.2 mm. Actual seeds embedded in a clay-ironstone matrix.

In their character they clearly occupy an intermediate position between the living species and the Eocene species next described.

V.17581 Holotype, figured Pl. VI, fig. 27. Seed in matrix showing form, with outer coat in section, and inner coat lying free within.

V.17582 Figured Pl. VI, fig. 28. Seed (complete).

V.17582 Figured Pl. VI, fig. 29. Seed attached to fragment of matrix, showing raphe.

V.18018 Seed lying in matrix, adjacent to internal cast of *Stratiotes neglectus*.

Aldrovanda ovata (Chandler)

Plate VI, figs. 24-26.

1925 *Nuphar ovatum* Chandler, Upper Eoc. Flora, p. 22, pl. iii, figs. 3a, b.

DIAGNOSIS: Neck about one-sixth of the total length; raphe conspicuous, with a very conspicuous point over the chalaza; ends of testa cells nearly flat, forming an almost smooth surface; combined thickness of coats nearly a quarter of the diameter of the seed. Average size 1.75 mm. $\times$ 1.4 mm.

HOLOTYPE: V.17485. Upper Eocene, Lower Headon Beds; Hordle, Hants.

DESCRIPTION: The seeds of this species differ from those of *A. intermedia* in being larger and more pointed. The cells of the outer coat are less inflated externally and the surface is therefore smoother, although the cells themselves are larger. Both coats are considerably thicker than in *A. intermedia* and much thicker than in *A. vesiculosa* L.

Length 1·75 mm. ; breadth 1·4 mm.

Actual seeds.

This species was first referred to *Nuphar* on the evidence of its external characters. Later when seeds of similar appearance were found at Galitsch and in the Bembridge Marl, and the structure of these was discovered, the Hordle specimens were re-examined and were found, on dissection, to have the same structure. They are therefore now transferred to the genus *Aldrovanda*.

V.17485 Holotype, figured Pl. VI, fig. 24 ; also figured Chandler, 1925, pl. iii, fig. 3a. Seed (perfect) ; from Hordle Cliff, Hants.

V.17486 Figured Pl. VI, fig. 25. Seed (broken) showing interior ; from Hordle Cliff.

V.17487 Figured Pl. VI, fig. 26. Inner seed-coat removed from outer ; from Hordle Cliff.

Presented by Miss M. E. J. Chandler, 1926.

Family RUTACEAE

Genus **ZANTHOXYLON** Linnaeus

1753 Spec. Pl., ed. 1, p. 270.

Zanthoxylon (?) costatum n. sp.

Plate VII, figs. 20, 21.

DIAGNOSIS : Seed reniform, hooked at the base, with basi-ventral chalaza ; surface rugose with about eighteen conspicuous, irregular concentric ridges running from chalaza to micropyle ; lining of seed-cavity mamillate.

HOLOTYPE : V.17595.

DESCRIPTION : Seed albuminous, reniform, hooked at the base, plano-convex, much inflated on the convex side. Hilum a triangular depressed area on the ventral margin, raphe-canal originating at the lower end of the hilum and passing through the thickness of the wall at the hooked end, until it enters the cavity at the large and round basi-ventral chalaza. Micropyle terminal on the ventral margin at the opposite end to the chalaza. External surface rugose and ornamented with about eighteen discontinuous ridges which run from the chalaza to the micropyle concentrically with the curved dorsal margin ; wall formed of the following layers : an outer coat (seen only in patches on the flat side) which is thin, black and shining, and formed of large flat thin-walled cells ; an inner coat which is thick, dull black, hard and brittle ; a thin light brown lining adhering closely to the cast of the seed-cavity, formed of thick-walled polygonal cells which give rise to a mamillate surface. This lining is fused with the thick coat outside it over the micropyle and chalaza.

Length 3 mm. ; breadth 2·3 mm.

Actual seed, with an internal cast occupying the seed-cavity.

DISCUSSION : When first seen the seed was perfect but cracked,

we therefore dissected one side in order to determine the anatomical characters. Subsequently several fragments, notably that showing the triangular hilum, decayed; we eventually restored the parts that remained. We feel sure that the seed belongs to Rutaceae, and that it is very close to, if not identical with, *Zanthoxylon*. Perhaps *Z. dissitum* most resembles it in form and structure.

We decided, however, to leave the determination uncertain because there are three points in which the fossil is not in absolute agreement with living species of *Zanthoxylon*. It differs in (i) the ridges on the external surface, which are more continuous and conspicuous than in living species; (ii) the basi-ventral chalaza, that of living *Zanthoxylon* being at the extreme base of the major axis; (iii) the lining of the seed cavity. In the fossil it is mamillate as described and adheres closely to the cast of the seed cavity and not to the testa. In the living *Zanthoxylon* it adheres to the testa and instead of being mamillate is composed of about two layers of hollow honey-comb cells.

The plano-convex form, indicating that two seeds were developed in the capsule, is often seen in living seeds of *Zanthoxylon*; but when only one seed attains to maturity its form is biconvex. The raphe canal of the fossil follows a slightly curved course, and this distortion is another result of development side by side with a second seed. The seeds of undoubted species of *Zanthoxylon* occur in the Lower Headon Beds of Hordle (Chandler, 1925, pp. 26-28, pl. iv, figs. 3, 5). Heer, Saporta and others describe many species founded on leaves.

V.17595 Holotype, figured Pl. VII, figs. 20, 21. Rock specimen showing impression, and the figured organic seed obtained from it.

Family RHAMNACEAE

Genus ZIZYPHUS Adanson

1763 Fam. Pl., II, p. 304.

Zizyphus paradisiacus (Unger) var. *paradoxus* nov.

Plate VII, figs. 22, 23; text-fig. 10.

- 1851 *Daphnogene paradisiaca* Unger, Denkschr. Ak. Wiss. Wien, ii, p. 167, pl. xxxvii, figs. 8-11, xxxviii, figs. 1-7.
- 1859 *Zizyphus paradisiacus* (Unger): Heer, Flora Tert. Helv., iii, p. 74.
- 1862 *Zizyphus paradisiaca* (Unger): Saporta, *Ann. Sci. Nat., Bot.* (4) xvii, p. 276, pl. xii, fig. 6.
- 1874 *Zizyphus paradisiacus* (Unger): Schimper, *Traité Pal. Vég.*, iii, p. 219, pl. ci, fig. 37.

DIAGNOSIS OF SPECIES: Leaf oval, sub-symmetric; nervation acrodromous; all tertiary nerves horizontal.

The variety is distinguished by the presence of secondary nerves.

DESCRIPTION : Leaf oval, sub-symmetric (extreme tip distorted and broken), base symmetric, lamina meeting the long slender petiole in a flowing curve ; margin with a few small prominences in the lower third, and with rounded or sigmoidal teeth above. Primary nerves three, prominent on both surfaces, acrodromous, the two lateral arising from the petiole in a sweeping curve at an acute angle and continuing sub-parallel to the margin until they loop with the secondary nerves near the apex ; secondary nerves few, all apical, arising at angles of about 55° from the midrib, secondary nerves from the laterals absent ; tertiary nerves given off from the three primaries at angles of about 90° (slightly more below, and less above, the middle), each tertiary nerve from the midrib unites with one from a lateral nerve, to form either a straight



FIG. 10.—*Zizyphus paradisiacus* (Unger) var. *paradoxus* n. Camera lucida drawing of a portion of the leaf to show the nervation and the sigmoidal teeth. V.17018, $\times$ about 3.

line, or a curved or angled line concave towards the base ; marginal tertiaries of equal strength with these, adjacent ones often unite to form loops with sharp outer angles at the notches of the teeth, or opposite to, and connected with, these notches by a short straight branch (text-fig. 10) ; quaternary nerves arising at right angles from the tertiary nerves and ultimately forming a fine network of free-ended nervules.

Length of lamina (incomplete) 34 mm. ; breadth 17.5 mm. ; length of petiole 9.5 mm.

Two impressions (counterparts).

REMARKS : The impression of the upper surface was labelled in pencil on the stone "*Zizyphus Ungerii*," probably by Gardner and Saporta during a visit to Gurnard Bay.

AFFINITIES : The Bembridge *Zizyphus* shows a combination

of characters which appears to be unknown in living species—ascending secondary nerves arising from the midrib and looping with the lateral nerves, and horizontal median and marginal tertiaries. We examined all the species of *Zizyphus* in Kew Herbarium, but although we found all the characters of the fossil, we did not find them united in a single species. Those most resembling it in the striking horizontality of *all* the tertiary nerves are certain East Asian species, of which *Z. glabrata* Heyne (= *Z. trinervia* Wall.) is one; but in no case could we find any secondary nerves given off from the midrib in these species, and in all, the lateral nerves are continued in an uninterrupted curve to the apex of the leaf.

It appears, therefore, that *Z. paradisiacus* var. *paradoxus* combines characters now scattered in the genus.

The genus *Zizyphus* has frequently been determined from fossil leaves. A comparison with Heer's and Saporta's figures of *Z. Unger*i (to which this specimen was referred) shows that in that species the tertiary nervation is much less horizontal. *Z. paradisiacus*, on the other hand, bears a close resemblance to the Bembridge fossils, judging from Unger's, Saporta's and Professor Laurent's figures. In none of these, however, are secondary nerves from the midrib depicted. The presence or absence of these nerves is, as we have seen, an important characteristic; we therefore regard the Bembridge fossil as a distinct variety of *Z. paradisiacus*, to which we give the name var. *paradoxus*.

V.17018 (counterparts) Figured Pl. VII, figs. 22, 23. One of these counterparts (fig. 22) is the impression of the upper surface; the other (fig. 23) that of the lower. The latter was purchased from A'Court Smith in 1877; the former was left in the main collection, and deteriorated, owing to the vicissitudes which this collection underwent.

Family RHAMNACEAE ?

Genus RHAMNOSPERMUM Chandler

1925 Upper Eoc. Flora, p. 30.

Rhamnospermum bilobatum Chandler

Plate VIII, figs. 1, 2.

1925 *Rhamnospermum bilobatum* Chandler, Upper Eoc. Flora, pp. 30, 31, pl. v, figs. 1a-c.

DIAGNOSIS: Seed globular, deeply bilobed; micropyle large, circular, at one end, closed by a plug; chalaza large, circular, median, in the deep groove between the lobes; surface ornamented with polygonal cells having beaded walls.

DESCRIPTION : Seed globular, bilobed owing to a deep longitudinal groove ; micropyle at one end, near the groove, a large circular opening, closed by a plug ; chalaza large, circular, median in the deep groove ; surface ornamentation of polygonal cells with beaded walls, which run transversely across the two lobes ; a light-coloured, semi-transparent skin lines the cavity and is fused with the testa round the chalaza. Diameter 2.25 to 2.75 mm. Actual seeds.

DISCUSSION : The species and genus was first described from the Lower Headon of Hordle. It occurs fairly abundantly at that horizon and is frequent in the Bembridge Marl. The real affinities of these fossil seeds are uncertain. The living seeds which most resemble them appear to be those of *Rhamnus catharticus* and *R. dahuricus*. These are similarly bilobed, have a similarly pitted testa, and a basal micropyle ; but the chalaza is apical, at the end of the groove, not median and lying within it. The hilum is basal and the raphe dorsal. In the fossil we have been unable to trace either hilum or raphe ; but if, as easily happens in *Rhamnus*, the latter were removed by friction, this is accounted for.

V.17596 Figured Pl. VIII, fig. 1. Organic seed lying in matrix, and showing groove between the lobes.

V.17597 Figured Pl. VIII, fig. 2. Organic seed lying in matrix, and showing micropylar aperture with groove in profile.

V.18064 Organic seed lying in matrix and showing inner seed-coat.

V.18065-71 Seven specimens of seeds (organic) lying in matrix and showing various aspects.

V.17017 Good seed.

Family **APOCYNACEAE**

Genus **APOCYNOSPERMUM** nov.

DIAGNOSIS : Seeds varying in shape from oval to lanceolate, pappiferous, anatropous, with long median raphe-ridge.

The name *Apocynospermum* may be regarded as a group name for fossil seeds which are clearly referable to the family Apocynaceae, but which cannot be assigned definitely to a living genus, either through lack of knowledge of the living, or the fossil, material. It follows that the different species of *Apocynospermum* need not be closely related generically.

Apocynospermum striatum n. sp.

Plate VIII, fig. 3.

DIAGNOSIS : Seed oval-lanceolate, flat or concavo-convex, conspicuously ribbed ; ribs many, occasionally anastomosing, becoming more regular towards the apex ; raphe linear, ventral ; pappus long, of uniseriate hairs without teeth, diverging from a central point.

HOLOTYPE: V.17598.

DESCRIPTION: Seed albuminous, pappiferous, anatropous, oval-lanceolate, flat or concavo-convex. In one specimen a few longitudinal folds form large ribs, but it is not easy to determine whether they are original or due to distortion. Surface with many irregular, conspicuous small ribs which occasionally anastomose, and become more regular towards the apex. Raphe linear on the ventral side; testa produced into a flat tongue or flap at the base, thin, of two layers—(1) a light brown outer layer of minute cells aligned in rows forming an irregular pitted surface on the exterior; (2) a hard, shining, uneven inner layer with closely placed polygonal or quadrate cells; endosperm not passing into the basal flap, but otherwise filling the cavity, enclosed by a delicate hyaline membrane, which is preserved. Pappus long, formed of simple, uniseriate hairs without teeth, spreading out from the central point of origin at the base like a wine-glass from its stem. Length 7.5 to 9 mm.; breadth 1.75 mm.; length of pappus 13 mm.

Impressions with remains of actual seeds. Endosperm represented by a creamy, granular substance.

At first sight this species with its longitudinal ribs might be mistaken for a Composite, but certain characters rule out such an ascription: (i) the presence of endosperm, (ii) the linear longitudinal raphe, (iii) the uniseriate hairs, (iv) the basal tongue or flap, (v) the striking irregularity of the ribs which sometimes anastomose. These characters all occur in Apocynaceae.

In some species of *Apocynum* the pappus, when detached, comes away as a single entity with a wine-glass-shaped base, as in the fossil. Probably other genera, which are not represented at Kew by seeds, or which do not show a detached pappus, may have a similar arrangement. Some species of *Apocynum* have striate seeds, but the striations are of a different character from those of the fossil and the seeds are only about half the size. Other examples of striate seeds are afforded by *Holarrhena* and *Wrightia*, but in these genera the seeds are at least twice as large as the fossil.

V.17598 Holotype, figured Pl. VIII, fig. 3. Impression of seed and pappus with some organic matter and remains of endosperm; with counterpart.

V.18072 Seed with pappus (good), showing striations.

V.18073 Specimen showing two seeds with pappus, also striations; one shows remains of endosperm.

V.18074 Seed without pappus, but with some organic matter.

***Apocnospermum rostratum* n. sp.**

Plate VIII, fig. 4.

DIAGNOSIS: Seed small and delicate, linear lanceolate, gradually narrowed at the upper end into a long slender style, and at the lower into a long slender beak, nearly flat except at the style

which is markedly concave; style pappiferous with delicate hairs given off at angles of about 45° ; testa thin, surface showing flat cells aligned obliquely from the long median raphe.

HOLOTYPE: V.17599.

DESCRIPTION: Seed small and delicate, anatropous, linear-lanceolate, narrowed very gradually at each end into a long beak, the upper being the style; but neither of these is quite perfect. Delicate lateral hairs are given off from the style at angles of about 45° , they represent the remains of the pappus. Ventral face more or less flattened except on the apical beak where it is markedly concave. The position of the raphe is represented by a sharp longitudinal ridge, median on the ventral side, not continued on to the beak. Testa evidently very thin; surface of small flat cells aligned obliquely upwards from the edges of the raphe ridge to the margin. Length (not quite complete) 7.5 mm.; breadth 0.62 mm.; length of raphe ridge 2.4 mm.; breadth 0.09 mm. Impressions.

AFFINITIES: The median ridge with diverging striae is not characteristic of Compositae, but it is of Apocynaceae. In both families slender beaks occur, but only in Apocynaceae have we seen them concave as in the fossil. In this family slender beaked seeds are found in *Anodendron*, *Kickxia*, *Strophanthus*, *Rhabdadenia* and *Urechites*. All these genera have larger seeds than the fossil, and in most of them, the proportion of breadth to length is relatively greater; but *Rhabdadenia* has linear-lanceolate beaked seeds with lateral hairs arising at angles of about 45° from the apical beak. The fossil is therefore comparable with this genus, but we refrain from naming it *Rhabdadenia* because of the great difference of size.

V.17599 Holotype, figured Pl. VIII, fig. 4, is an impression of the ventral side of a seed.

V.18075 Probably the same, but is badly preserved.

Apocynospermum elegans n. sp.

Plate VIII, figs. 5, 6.

DIAGNOSIS: Seed lanceolate, thin, slightly concavo-convex in section; raphe linear, scarcely prominent; testa ornamented with longitudinal rugosities, lining of seed cavity formed of small quadrilateral cells; pappus of simple hairs arising from the whole apical surface.

HOLOTYPE: V.17601.

DESCRIPTION: Seed pappiferous, albuminous, anatropous, lanceolate, rounded or pointed at the apex, thin, slightly concavo-convex in section; raphe-ridge linear, median on the ventral face, scarcely prominent; testa thin, produced into a small flap at the base, slightly rugose with small longitudinally elongate prominences, internally with small quadrilateral cells giving rise to trans-

verse ripples and longitudinal striations. The small cells are sometimes obscured by large quadrilateral markings on the hyaline coat of the endosperm. Endosperm occupying the whole seed cavity but not extending into the basal flap. Pappus of simple, unbranched hairs without teeth (incomplete owing to the fracture of the stone), nearly straight, arising from the whole of the apical surface.

Length, excluding pappus, 6 to 8 mm. ; breadth 0·5 to 0·8 mm.

Impressions with some organic structure remaining. Endosperm represented by a creamy granular substance.

AFFINITIES : As in the preceding species, this fossil is distinguished from Compositae by its anatropous, albuminous seed with median longitudinal raphe, and pappus of simple uniseriate hairs ; but these characters would relate it to Apocynaceae. In this family *Prestonia*, *Forsteronia*, *Pottsia*, *Cleghornia* all have narrow seeds with a triangular or ligulate area from which the pappus is given off as in the fossil, and some are rugose with elongate tubercles, but all are larger—from one and a half to twice as large. *Mitozus*, a Brazilian genus, and *Echites*, which ranges from North to South America, are comparable in size and have similar pappus-bearing apices, and long median scars on the ventral faces of the seeds. We were unable to study the cell structure of these genera, but it is possible that if we had been able to do so, we could have placed the fossil in the genus *Echites*. Without such a comparison we are obliged to leave it in the provisional genus *Apocynospermum*.

V.17601 Holotype, figured Pl. VIII, fig. 6. Impression of seed with pappus, showing remains of organic matter with cells of interior of seed and endosperm.

V.17600 Figured Pl. VIII, fig. 5. Impression of seed and pappus, showing median raphe, a little organic matter, and remains of endosperm.

V.18076 Impression of seed without pappus, showing hilum.

***Apocynospermum dubium* n. sp.**

Plate VIII, fig. 7.

DIAGNOSIS : Seed linear-oval, flat, with narrow margins, a median and two lateral ridges ; testa striate, without a collar at the apex, although it is constricted.

HOLOTYPE : V.17602.

DESCRIPTION : Seed pappiferous, flat, linear-oval, with narrow margins, and a median and two lateral ridges ; testa striate, produced into a small flap below, ragged and uneven at the apex, with no definite collar and with a constriction between seed and pappus. Pappus broken above, a dense tuft of simple uniseriate hairs, circular in section below, and rounded at the base. It is detached from the seed. Length (pappus incomplete) 7·6 mm. ; length of seed (exclusive of pappus) 3 mm. ; breadth 0·75 mm. Impression.

This beautiful seed is unfortunately preserved as an impression only, and does not show much cell structure. It was compared with Compositae, but the absence of an apical collar, the constriction between seed and pappus, the fact that the pappus is a dense tuft and not a peripheral ring of hairs, and the mode of detachment of the pappus from the seed forbid an ascription to this family and ally the fossil with Apocynaceae or Asclepiadaceae; probably with the former. We are unable to make any closer determination.

V.17602 Holotype, figured Pl. VIII, fig. 7, represents the impression of a seed and pappus.

Apocynospermum?

V.18077-79 Three specimens showing impressions of pappus; indeterminate.

V.17050 Poor seed with good pappus impression.

Family ASCLEPIADACEAE

Genus **PHYLLANTHERA** Blume

1826 Bijdr. Fl. Nederl. Ind., p. 1048.

Phyllanthera vectensis n. sp.

Plate VIII, figs. 8-11.

DIAGNOSIS: Seed lanceolate-oval, thin, concavo-convex in section, with a narrow rim broadening at the apex; raphe linear on a longitudinal ventral ridge; surface cells oblong and inflated.

HOLOTYPE: V.17604.

DESCRIPTION: Seed pappiferous and anatropous, lanceolate-oval, thin, having a narrow flange or rim which becomes broader at the rather ragged apex and is prolonged into a flat conical tongue at the base. This flange marks the limits of the endosperm which occupies an area regularly lanceolate-oval in outline. In transverse section the seed is convex on the dorsal side, and concave on the ventral; raphe a linear ridge, median on the ventral side. Pappus a close tuft of simple, unbranched hairs without teeth, sometimes with conspicuous ripples. Surface ornamentation of oblong, inflated cells, giving a square-cobblestone effect; cells sometimes more lenticular over the middle of the dorsal surface. Length 7 mm.; breadth 1.1 mm. Actual seeds (fragmentary) and impressions of both surfaces; endosperm represented by a creamy, granular substance.

The seeds which most resemble the fossil belong to the subsection Periploceae of the Asclepiadaceae. The genera *Periploca*, *Pentamera*, *Hemidesmus*, and *Cryptolepis* show a general resemblance; but *Periploca* is larger, more oblong and less symmetric, although its cell-structure is similar, *Pentamera* and *Hemidesmus*

are stouter and rougher, *Cryptolepis* is broader and stouter. The genus *Phyllanthera* shows all the characters of the fossil, and *P. perakensis* King & Gamble, is the most closely allied species; it has a similar graceful, symmetrical form, the same cell-structure, the same rippled pappus, and it is of comparable dimensions (length 7.5 mm.; breadth 2 mm.). That species is a liane of the Malay Peninsula.

- V.17604** Holotype, figured Pl. VIII, figs. 9, 10. Impression of seed with part of pappus and much organic matter, some of which has now disintegrated.
- V.17603** Figured Pl. VIII, fig. 8. Seed with pappus, much of the actual testa, and granular substance representing endosperm.
- V.17605** Figured Pl. VIII, fig. 11. Seed without pappus showing hilum; with good organic substance remaining; figured to show cell-structure.
- V.18080** Seed (no pappus) with remains of organic matter and endosperm. Close beside it is a fragment of *Apocynospermum elegans*, also with organic matter remaining.
- V.18081** Very poor impression of seed.
- V.18082** Probably *Phyllanthera vectensis*.

Genus TYLOPHORA R. Brown

1809 Mem. Werner. Soc., I, p. 28.

Tylophora antiqua n. sp.

Plate VIII, fig. 23.

DIAGNOSIS: Seed thin, spatulate, rounded at the base, truncate at the apex, concavo-convex in section, with a thin narrow rim having an entire margin; raphe median with fibres diverging from it over the spatulate area of the chalaza; cells of rim polygonal, aligned in rows, those of body coarse and irregular.

HOLOTYPE: V.17606.

DESCRIPTION: Seed thin, spatulate, rounded at the base, truncate at the apex, concave on the ventral side, convex on the dorsal, surrounded, except at the apex, by a well-defined, thin and narrow rim with an entire margin. Raphe median on the ventral face, marked by a strand of fibres, which, at about two-thirds of the length from the apex, diverge over a narrow spatulate area, corresponding to the chalaza. Surface of the rim of small, fairly uniform, polygonal cells aligned in longitudinal rows; cells over the body of the seed coarser and more irregular but with a general tendency, in the lower part, to diverge from the chalaza towards the margin. An impression with very fragmentary remains of the actual seed, especially on the margin and raphe. The cells of the ventral surface are preserved on the impression, and those of the dorsal surface on the remains of the testa. Length 8 mm.; breadth 3.5 mm.

AFFINITIES: Thin, spatulate, concavo-convex seeds with rimmed margins are common in the family Asclepiadaceae and occur in *Asclepias*, *Gomphocarpus*, *Vincetoxicum*, and *Tylophora*. The chief characters by which these seeds may be distinguished from one another are the relative proportions, especially of the rim, and the cell-structure of the testa. Of the genera named, *Tylophora* most resembles the fossil; *Vincetoxicum* has a coarser, more irregular cell-structure, and the cells on the margin are not aligned, moreover the surface is more rugose; certain species of *Gomphoceras* (*Acerates*) are similar in size, but broader in the middle; they are also more rugose, and have the rim and raphe less clearly defined; *Asclepias spinosa* is similar in size and shape, but is stouter, more rugose, and it has a different cell-structure.

Tylophora hirsuta Wight has seeds of exactly the same form and approximately the same size as the fossil, with the same kind of raphe, rim, and cell-structure. The cells of the rim are longitudinally aligned as in the fossil, but they are of the same size as the cells on the body of the seed, not smaller as in *T. antiqua*. *T. exilis* Colebr., although otherwise less like, has rim-cells markedly smaller than those on the body. The species of *Tylophora* are shrubs and undershrubs, living chiefly in the East Indies, but also in Australia, with a few species in South and West Africa and Madagascar.

Heer describes and figures the fruits and leaves of an Asclepiad from Oeningen under the name *Acerates veterana* (Heer, 1859, iii, p. 20, pl. civ, figs. 5-8), which he places near to the living *A. longifolia*. Of the two seeds figured, Heer suggests that one (fig. 7) may be the seed of *A. veterana*, whilst the other (fig. 7b) may belong to a different species. So far as can be judged from the inadequate figures and descriptions, neither of these seeds resembles the Bembridge fossil. That referred to *A. veterana* is quite unlike it, while the other is broader, more ovate, and apparently much smaller.

V.17606 Holotype, figured Pl. VIII, fig. 13, shows the impression of the ventral surface of the seed with fragmentary carbonaceous remains.

GENERAL NOTE ON THE OCCURRENCE IN OTHER DEPOSITS OF FOSSIL SEEDS OF APOCYNACEAE AND ASCLEPIADACEAE

Under the name *Cypselites*, Heer (1859, iii, pp. 1-6, pl. ci, figs. 1-19) describes many, more or less elongate, pappus-bearing seeds which he refers to the family Compositae. In our opinion the majority of these should be referred to Apocynaceae or Asclepiadaceae, and the same applies to his species *Bidentites antiquus* (1859, III, p. 6, pl. ci, fig. 20). This seed shows the well-marked, V-shaped apex characteristic of many Apocynaceae, e.g. *Microchites*; it also shows, in common with many species of *Cypselites*,

two symmetrically-placed, lateral grooves. These grooves occur commonly in Apocynaceae and Asclepiadaceae, and they mark either the limit of the endosperm or of the embryo within the endosperm. Many species of *Cypselites* also show an oblique apex such as is characteristic of many Apocynaceae. The median raphe-ridge can of course be seen only when the ventral side of the seed is represented.

Ettingshausen was perhaps the first worker to suggest that Heer was mistaken in his *Cypselites*. After determining an Apocynaceous seed from Bilin (Ettingshausen, 1868, p. 218, pl. xxxvi, fig. 21), he states that in his opinion *Cypselites costatus* Heer (1859, p. 4, pl. ci, fig. 9) is an Apocynaceous seed also, and probably the same as *Echitonium superstes* Unger (1866, p. 18, pl. v, fig. 11).

We do not propose to enter into a detailed criticism of Heer's species, indeed it would be impossible to do so without carefully examining his actual types, but we offer here a few criticisms of his general discussion on the subject. In this discussion he considers whether or not the specimens could be referred to Apocynaceae; but rejects such an alliance, because in those genera of Apocynaceae which he was able to study, the hairs were more soft and fine, and the seeds smaller and not striate. But there are numerous Apocynaceous genera with striate seeds which are as large as, or larger than, Heer's fossils, e.g. *Holarrhena*, *Micrechites*, *Pottsia*, *Strophanthus*; and the hairs, if fine, are frequently agglomerated, especially at the base, so as to appear coarser than they really are.

Heer also rejects Asclepiadaceae, because, he states, the seeds are always flat and rimmed in this family, are neither ribbed, striate nor beaked, and, again, the hairs are fine. It is true that in Asclepiadaceae the seeds are often thin, but they are not always flat. In *Tylophora* and *Phyllanthera*, for example, they are concavo-convex with a strong median raphe-ridge on the ventral face, and the rim may be almost absent except at the base. Again, some genera, e.g. *Periploca*, have edges partly inrolled on the ventral face, so that an impression of the ventral side with its raphe-ridge would suggest a narrow ribbed seed. Further, many Apocynaceae and a few Asclepiadaceae have beaked seeds, e.g. *Strophanthus*, *Micrechites*, *Anodendron* among the former, *Pergularia* among the latter.

The rippled pappus seen in his figures is explained by Heer, rather ineffectually, as caused by movement of mud and water about the seed, but no such explanation is necessary, for rippling of the pappus is characteristic and common both in Apocynaceae and Asclepiadaceae, and is due to the overlapping arrangement within the pod of the closely packed seeds.

Lastly, it is to be noticed that, with one exception (*C. Regeli* Heer), both Heer and Saporta describe the hairs in *Cypselites* as

simple. The term is somewhat ambiguous as applied to Apocynaceae, Asclepiadaceae, and Compositae. In the two first-named families, the hairs are formed of uniseriate cells ; in the last-named they are never uniseriate except at the extreme tip, and the only "simple" hairs, if the term be used to signify hairs which are not branched, are formed of from two to three parallel cells in series. In his comparison of *Cypselites* with Asclepiads, Heer states "besteht der Haarschopf der Asclepiadeen aus viel zarteren, feineren Haaren, als bei den fossilen Arten" ; but if the hairs of the fossils really resembled those of Asclepiadaceae, then they must have differed from those of Compositae. His observation either of the fossils or of the living genera must therefore have been inadequate.

Family LABIATAE

Genus **MELISSA** Linnaeus

1753 Spec. Pl. ed., 1, p. 592.

Melissa parva n. sp.

Plate VIII, figs. 15, 16.

DIAGNOSIS : Nut small, oblong, inflated, bluntly angled on the ventral face ; style gynobasic, and contiguous to the basal scar of attachment, which is pierced by a median hole and emarginate where the stylar canal passes through ; cells of surface flat, polygonal or quadrilateral, somewhat longitudinally aligned, not very conspicuous.

HOLOTYPE : V.17607.

DESCRIPTION : To the above may be added that the nut has a fairly large scar of attachment with smooth edges, which are emarginate at the upper end where the stylar canal passes into the nut ; scar filled by a plug of white mineral matter pierced by a central canal. The cells of the surface are rather obscure. Length 1.25 mm. ; breadth 0.5 mm.

REMARKS : The actual nut with carbonised pericarp is preserved. Its structure is almost identical with that of *M. officinalis* Linn. The only differences are the smaller size (*M. officinalis* length 1.5 to 2 mm. ; breadth 0.75 to 0.9 mm.), blunter base, more clumsy oblong form and less well-defined cell-structure of the surface ; the cells of *M. officinalis* are identical in character but larger, and they have more conspicuous walls.

The genus *Melissa* ranges from Europe, through the Orient, Central Asia, and the Himalayas, to Western China and the Malay Peninsula. It also occurs in the Bahama Islands. *M. officinalis* is native in Europe (including the Mediterranean region), North Africa and the Orient.

V.17607 Holotype, figured Pl. VIII, figs. 15, 16. Nut removed from matrix.

Genus **AJUGINUCULA** nov.

DIAGNOSIS : Nutlet sub-ovoid, convex dorsally, flat ventrally ; scar of attachment very large, occupying almost the whole ventral surface ; dorsal surface conspicuously and regularly pitted ; the pits of medium size, about 16 rows across the dorsal surface.

The nutlets by their form and character, particularly by their large scar of attachment, clearly belong to the section Ajugoideae of the family Labiatae ; but we have been unable to find any living genus to correspond exactly with them.

GENOTYPE : *A. Smithii* n. sp.

Ajuginucula Smithii n. sp.

Plate VIII, figs. 17, 18.

DIAGNOSIS : That of genus.

HOLOTYPE : V.17608.

DESCRIPTION : The nutlet is obovoid, the apex being rounded, the base pointed. The dorsal face is roundly convex, the ventral face flat or slightly concave over the large round scar of attachment, which occupies nearly the whole of it. The dorsal face, and upper part of the ventral face, are ornamented with deep polygonal pits of uniform size aligned more or less regularly in longitudinal rows. The scar of attachment is finely granulate. Length 0.9 mm. ; breadth 0.7 mm. A carbonised nutlet.

AFFINITIES : The nutlet is comparable in size with those of *Teucrium*, many of which are not more than 1 mm. long ; but its form is more graceful than those of any species of *Teucrium*, in which the nutlets are all rounded below, not narrowed as is the fossil. The nutlets of *Cymaria* are also similar in size, and those of *C. elongata* are not unlike in shape, but are yet more narrowed at the base than the fossil. In neither genus does the sculpture of the nutlets closely resemble that of *Ajuginucula*. In *Teucrium* the seeds are either much more finely or much more coarsely pitted than in the fossil, and in all species the arrangement of pits is less uniform. In *Cymaria* the pits are still coarser, there being only 5 or 6 in the width of the nut, and these are elongate longitudinally below like the large pits of *Ajuga*.

Whilst therefore the general characters are those of Ajugoideae, no genus shows all its characters, so that we have been obliged to give a new generic name. The species has never been recorded fossil. We have therefore given the specific name *Ajuginucula Smithii* in honour of J. E. A'Court Smith, to whose tireless energy we owe this great collection.

V.17608 Holotype, figured Pl. VIII, figs. 17, 18. Nut removed from matrix.

Family **BIGNONIACEAE**Genus **CATALPA** Scopoli1777 *Introd. Hist. Nat.*, p. 170.**Catalpa rugosa** n. sp.

Plate VIII, fig. 19.

DIAGNOSIS : Seed large, concavo-convex, transversely oval, with long stiff lateral wings, without contorted fibres at the junction of wing and body, concave in both directions on the ventral face, rimmed at base and apex ; surface rough.

HOLOTYPE : V.17609.

DESCRIPTION : Seed anatropous, elongate-oval, strongly rimmed at base and apex, with striate lateral wings apparently composed of stiff hairs. Body of seed (excluding the wings) transversely-oval, bisymmetric about a median line through the raphe, with a slightly emarginate apex, ventral face concave ; raphe linear, hilum basal, chalaza apical, surface nodular especially above. Length (including margin) 3.5 mm. ; length (without margin) 2.75 mm. ; breadth (including imperfect wings) 14 mm. ; breadth (excluding wings) 4.5 mm. An impression of the ventral surface.

The conspicuous warts all over the surface are due to mineral changes following upon exposure to damp air, for they are distributed over the whole surface of the stone.

AFFINITIES : A comparison with seeds of Bignoniaceae shows that the following are the most distinctive diagnostic characters :

- (i) The stiff, coarse hairs of the lateral wings.
- (ii) The direction of the hairs, straight out from the sides, with little or no contortion at the junction of wing and body so characteristic of most genera in the family.
- (iii) The transversely-oval form.
- (iv) The concavity of the ventral face both longitudinally and transversely.
- (v) The marked rim at base and apex.

We have found characters (i) and (ii) above, only in the subsection *Trichospermae* (§ *Tecomae*), and the only comparable genera are *Chilopsis* and *Catalpa*. The ratio of breadth to length in the fossil is 2 : 1, the same as in *Chilopsis*, a desert plant of North America, which has the same general form, apical rim, and a similar but smoother surface. The ventral face of *Chilopsis* is concave, but the concavity is less marked than in the fossil, and tends to become a convexity towards the wings. Moreover, the hilum and linear raphe are more marked.

Catalpa has a concave lower surface much more resembling the fossil, and specimens of the Japanese *C. Kaempferi* Sieb. &

Zucc. (= *C. ovata* G. Don), often show the ratio breadth : length = 2 : 1, although the seeds are smaller. The hilum is less marked than in *Chilopsis*, and in this respect also, *Catalpa* agrees more closely with the fossil. Some species though rough are relatively so much broader as to be useless for comparison. The Central American species are both larger and flatter, and have stiff wings, hairy towards the extremities; the West Indian *C. punctata* is almost linear and very small, but it is hairy on the ventral surface, which suggests that some of the roughness of the fossil may be due to hair-bases. The striations over the body are more marked in the living *Catalpa* and *Chilopsis* than in the fossil, but their absence may be due to the bad state of preservation. Taking the characters as a whole, the resemblance to *Catalpa* appears to be greater than the resemblance to *Chilopsis*.

From the Oligocene of Aix, Saporta describes and figures two species of *Catalpa* from seeds (Saporta 1889, p. 62, pl. viii, figs. 7-15). The Bembridge fossil differs in size and shape from his two species more than they differ from each other. Although it is about as broad transversely, it is longer from base to apex than the Aix specimens. Judging from Saporta's figures, and from his reference to the raphe, we conclude that his specimens show the ventral face, but he does not say that it is concave, nor does he say that the surface is rough. We cannot, therefore, refer the Bembridge seed to either of his species.

V.17609 Holotype, figured Pl. VIII, fig. 19. Impression of winged seed, ventral surface.

Genus **RADERMACHERA** Zollinger & Moritzi

1854 Syst. Verz. Pfl. Ind. Archip., I, p. 53.

Radermachera pulchra n. sp.

Plate VIII, fig. 20.

DIAGNOSIS: Seed, including long diaphanous striate wings, transversely oblong, flat; embryo flat, aligned obliquely; testa with fine striae directed from hilum upwards over the body, but sharply contorted at the junction of wings and body.

HOLOTYPE: V.17610.

DESCRIPTION: Seed flat, including long diaphanous striate wings, transversely oblong, hilum basal on the ventral side; embryo large, obovate, flat, lying obliquely in relation to the wings; testa with delicate but conspicuous striae which diverge from the hilum, bend sharply over the edges of the embryo, and thereafter follow a horizontal direction in the long lateral wings; wings stiff, gradually becoming more diaphanous towards the tips until at last they become indistinguishable from the surrounding matrix. Length (base to apex) 3 mm.; breadth (including incomplete wings)

15 mm.; probable breadth when perfect 19 mm. (?) ; breadth of embryo 1.2 mm.; breadth of seed (exclusive of wings) about 2.5 mm. One impression of the ventral surface.

AFFINITIES: A study of the seeds of Bignoniaceae in Kew Herbarium leaves no doubt that this delicate impression belongs to *Radermachera*. In general form and size, character of wings, size and shape of embryo, character and direction of striae, it is nearest to *R. sinica*, Hance (Pl. VIII, fig. 22), a plant of China and Formosa, but as a rule the embryo of this species is less oblique with regard to the wings (although occasional specimens display the same degree of obliquity). Also the wings of this species are shorter (11 mm. from tip to tip), and only about five times the breadth of the body, whereas the wings of the fossil, when perfect, must have measured about eight times the breadth of the body. *R. glandulosa* Miq. (Pl. VIII, fig. 21), a plant of Java and the Malay Peninsula, resembles the fossil more closely, in its obliquity, its proportionately longer wings, and its well-defined embryo delimited by a ridge on the testa. Its wings measure 15 mm. from tip to tip, eight times the breadth of the body. *R. glandulosa* is, however, smaller; the wings are less oblong than in the fossil and *R. sinica*, and the striation is less conspicuous, especially on the body of the seed. *Radermachera* is a genus of small trees found in China, Formosa, Malaya and the East Indies. (A leaf which may possibly belong to *Radermachera* is described on p. 155.)

V.17610 Holotype, figured Pl. VIII, fig. 20. Impression of ventral surface of winged seed.

Genus **INCARVILLEA** A. L. de Jussieu

1789 Gen. Pl., p. 138.

Incarvillea pristina n. sp.

Plate VIII, figs. 23, 24.

DIAGNOSIS: Seed anatropous, narrowly winged except at the base, oval, concave on the ventral face; hilum large and basal, chalaza apical; body of seed emarginate at the apex; testa striate, the striae diverging upwards and outwards from the hilum and median raphe, but bent downwards at the junction of body and wing.

HOLOTYPE: V.17611.

DESCRIPTION: Seed anatropous, winged, oval, concave on the ventral face; hilum and micropyle contiguous, basal, represented by a large, ovoid, gaping scar; raphe linear, prominent, median on the ventral face (marked by a strong groove in the impression); chalaza apical at the junction of body and wing. Body obovate, emarginate at the apex; wing with no definite line of demarcation from the body, but its limits shown by the

angular bend in the surface striae. Testa formed of coarse, conspicuous, elongate cells which diverge upwards and outwards from the raphe and chalaza, then recurve sharply towards the base where the wing arises, *i.e.* at rather less than three-fifths of the distance between raphe and margin. These cells give a striate appearance to the surface which may possibly have been further ornamented with prominent rugosities. Length 3.5 mm.; breadth 2.6 mm. One impression of the ventral surface with remains of the actual testa adhering.

AFFINITIES : Seeds of certain species of *Incarvillea* are in close agreement with the fossil. They are winged in the same way; the testa is formed of similar coarse, elongate cells on body and wing, the striations due to these cells bend, where the wing arises, sharply towards the base; the micropyle, hilum and chalaza are similar and occupy the same relative positions, while the body of the seed is emarginate at the apex.

The characters are best represented in *I. grandiflora* Bureau & Franchet, but the seeds of that species are larger (length 5 to 6 mm.; breadth 3 mm.) and the striations curve more sharply towards the base. In *I. compacta* Maxim. the seeds are identical in size but less like the fossil in cell-structure. The former species is found in grass-lands of the Western Chinese mountains at altitudes ranging from 9,000 to 13,000 feet. The latter species is a native of Western China and Tibet.

V.17611 Holotype, figured Pl. VIII, figs. 23, 24. Impression of ventral face of seed with small marginal wing, some organic matter remaining. Impression of nut of *Cladiocarya* on same block.

Family ACANTHACEAE

Genus ACANTHUS Linnaeus

1753 Spec. Pl., ed. 1, p. 639.

Acanthus rugatus n. sp.

Plate VIII, figs. 26, 27.

DIAGNOSIS : Seed large, flat, oval, campylotropous, conspicuously emarginate at the hilum and micropyle; testa conspicuously crumpled and finely pitted; smaller than *A. volubilis* and *A. ilicifolius*.

HOLOTYPE : V.17612.

DESCRIPTION : To this diagnosis we may add that the hilum and micropyle are contiguous so as to form a single scar. The testa is crumpled into large, contorted rugosities, finely pitted. Length 6 mm.; breadth 4 mm. Impressions (counterparts).

The campylotropous character is clearly shown, even in the

impression, by the curvature of the surface ornamentation, the absence of a raphe line, and the single scar representing hilum and micropyle.

AFFINITIES : Except in its smaller size, this seed corresponds very closely with the seeds of *Acanthus ilicifolius* Linn. In this, and in the allied species *A. ebracteatus* Vahl and *A. volubilis* Wallich, the large campylotropous seeds are covered by a rather thin, finely punctate, leathery testa, which is raised into large, contorted, vesicular tubercles.

The fossil was compared with all fruiting species in Kew Herbarium. It does not agree with the seeds of Mediterranean or African species, which are smooth, but with those of the three allied species named above. Of these three, *A. volubilis* is nearest in size, and *A. ilicifolius* in shape, *A. volubilis* being more ovate with a more terminal micropyle and hilum.

The three species are found in the saline waters of the mangrove swamps of Eastern Asia and Australia, a similar habitat to that of *Acrostichum aureum*, to which species *A. Lanzaeanum* is related. The species may therefore indicate the proximity of the sea.

V.17612 Holotype, figured Pl. VIII, figs. 26, 27. Impression of the seed, with counterpart.

Family **CAPRIFOLIACEAE**

Genus **ABELIA** R. Brown

1818 In Abel, Narr. Journ. China, p. 376.

The living genus *Abelia* is characterised by an inferior fruit with accrescent calyx produced above into a whorl of linear, lanceolate, oval, ovate, obovate, or spatulate wings. These may be free where they arise, or they may be united at their extreme bases; they are slightly recurved at the edges in the upper part so as to give a transverse section which is convex above and concave below. The number of wings is two, four, or five (rarely three in *A. Graebneriana*). There are usually three or more sub-parallel primary nerves in each wing, prominent on both surfaces, usually more prominent on the lower surface, but rarely on the upper. Certain species have a very conspicuous midrib and obscure lateral nerves; in these the nervation is pinnate, the secondary nerves branching at fairly obtuse angles and uniting to form loops. Other species have no conspicuous midrib but, instead, there are several equally pronounced primary nerves which bifurcate two or three times at acute angles, and occasionally anastomose. Both surfaces of the wings show small irregular polygonal cells, and there are large cells (? air-spaces) in the interior of the lamina.

The fruit varies in shape from cylindrical to ovoid; it is more or less markedly ribbed or angled, the ribs being continued into the midribs of the wings. The surface shows irregular, polygonal

cells which are oblong and aligned longitudinally over the ribs ; the area of alignment expands towards the apex and sometimes embraces the whole circumference. The apex is flattened and expanded to form a circular, quadrilateral or quinquelateral disc which usually has a raised marginal or sub-marginal rim. Both fruit and wings are frequently covered with short, stiff, scattered hairs.

The genus *Abelia* inhabits China (especially the mountain woods of Hupeh and Szechuan) and Japan. It has species in the Himalaya, one (*A. corymbosa*) in Turkestan and Baluchistan, and a few in Central America. The Bembridge fossils resemble the Old World species.

Every character found in the four following fossils is also found, with two exceptions, in one or another species of the genus *Abelia*, (a) the *normal* occurrence of three wings as in *A. triolata*, (b) the large wings seen in *A. triolata*. These exceptions are discussed later (p. 137).

***Abelia quadrialata* n. sp.**

Plate VIII, figs. 29-31 ; text-fig. 11.

DIAGNOSIS : Fruit inferior, cylindrical, with about ten longitudinal ribs and four large apical wings ; apex of fruit square, the angles between the wings being produced into short tongues ; nerves diverging from the base of the wing, bifurcating, and sometimes anastomosing.

HOLOTYPE : V.17614.

DESCRIPTION : *Fruit* : Inferior, cylindrical, narrowed at the base, with about ten longitudinal ribs ; the apex is four-angled with a central boss, and the angles are produced into short tongues between the wings (text-fig. 11). Calyx accrescent, produced into four large, apical, obovate or spatulate, expanded wings, slightly recurved at the tips and edges, completely free at the base. Each wing has several prominent nerves which diverge from the base, bifurcate at acute angles, and anastomose fairly frequently ; the nerves are continued to the margin (text-fig. 11). Length of fruit about 10 mm. ; breadth 1-1.5 mm. ; length of wings 9.5-14 mm. ; breadth 4.5-6 mm. Impressions ; several specimens are represented by counterparts.

Seed : A fragment preserved in V.18084 is cylindrical, with a slight longitudinal depression ; its surface is ornamented with irregular quadrilateral crumples or ridges. Actual organic substance.

Many living species of *Abelia* are four-winged, and the wings of *A. quadrialata* fall within the limits of size and form observed. Cylindrical fruits, comparable in shape and dimensions occur in *A. spathulata* Siebold & Zuccarini (with five ribs), *A. chinensis*

R. Brown (with ten ribs) and other species. Sharply angled apical rims are found in many species, notably in *A. chinensis*, but we have not seen any produced into short appendages between the wings. The fan-like nervation is met with, although not so conspicuously, in *A. serrata* Siebold & Zuccarini, and this normally two-winged species has a tendency to produce four or five wings by subdivision. The quadrilateral cells of the seed agree with those of *A. spathulata*.

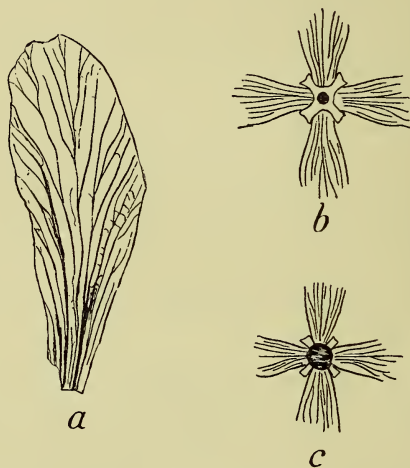


FIG. 11.—*Abelia quadrialata* n. sp. *a*, Camera lucida drawing of a wing to show nervation. Specimen V.17676, $\times 4$. *b*, Diagrammatic drawing of an impression of the upper surface of the wings showing the apical disc of the fruit. *c*, Diagrammatic drawing of an impression of the lower surface of the wings.

The bulk of the evidence, therefore, supports the ascription of the fossil to the genus *Abelia*.

Under the name *Ononis vetusta*, Ettingshausen (1869, pl. lv, figs. 8, 9) figures an imperfect fossil which is probably akin to *Abelia quadrialata*. The relative positions of the segments suggest a cruciform arrangement, and the nervation and shape strongly recall *Abelia*. The wings are smaller than those of *A. quadrialata*.

V.17614 Holotype (counterparts), figured Pl. VIII, figs. 30, 31, shows the fruit, apical disc and parts of two wings.

V.17613 Figured Pl. VIII, fig. 29. Impressions of four wings, two complete, one nearly complete, one broken.

V.17676 Text-figure 11, to show nervation. Impression of wings.

V.18083 Specimen broken into four portions, shows impression of fruit with wings (distorted). Fruit (incomplete at base) 6 mm. long. On the same specimen is the impression (counterparts) of a good fruit of *Clematis vectensis*.

V.18084 Impression of fruit and parts of four wings with counterpart. Fruit (incomplete) measures 6 mm. ; breadth 4 mm.

- V.18085 Impressions of two opposite wings (complete). Length of longest 14 mm.; length of shortest 9.5; breadth of both 6 mm. The remaining wings are probably broken, although the form of the shorter wing suggests that possibly two are fused.
- V.18086 Impression of fruit, and counterpart, with small parts of two wings.
- V.18087 Parts of four wings, impression with counterpart.
- V.18088 Parts of two wings, impression with counterpart.
- V.18089 Impression of wing and broken fruit.
- V.18090 Impression of wing (good nervation).
- V.18091-95 Five specimens (fragmentary) showing impressions of wings.

***Abelia quinquealata* n. sp.**

Plate VIII, figs. 32, 33; text-fig. 12.

DIAGNOSIS: (Actual fruit unknown) wings 5, elongate-oval, sub-equal, in a flattened whorl, with one median nerve and a few sub-parallel lateral nerves reaching the margin.

HOLOTYPE: V.17615.

DESCRIPTION: Actual fruit unknown, only the apical disc and wings having been seen.

Apical disc with a raised rim, circular on its inner, and sharply five-angled on its outer, circumference, the angles being produced radially into short spoke-like ribs between the wings (text-fig. 12*b*).

Wings five, sub-equal, elongate-oval, spreading in a nearly horizontal plane; rather thick at the centre, with one median nerve, and a few sub-parallel lateral nerves, scarcely salient and extending to the margins (text-fig. 12*a*). Cells of the upper surface small,

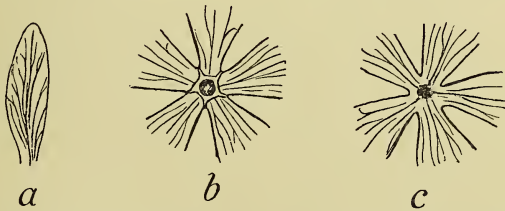


FIG. 12.—*Abelia quinquealata* n. sp. *a*, Camera lucida drawing to show nervation; part of specimen V.17616, $\times 4$. *b*, Diagrammatic drawing of the apical disc, as seen on an impression of the upper surface of the wings. *c*, Diagrammatic drawing of the median area as seen on an impression of the lower surface of the wings.

arranged fairly regularly in longitudinal rows, with much larger polygonal cells (? air-spaces) occupying the thickness of the wing; cells of the lower surface polygonal, larger and more irregular than those of the upper.

Diameter of whorl varying from 6.5 to 9 mm.; length of wings 2.75 to 5 mm.; breadth 1.5 mm.

Impressions with patches of organic substance near the centre. Two of the three specimens are represented by counterparts showing the lower and upper surfaces of the whorls of wings.

The form of the wings and the apex of the fruit are in close agreement with species of *Abelia*, particularly *A. chinensis* and *A. spathulata*. But both these species are somewhat larger (diameter of expanded wings 9.5 mm. in *A. chinensis*, 13 to 15 mm. in *A. spathulata*). Similar, but more complicated, nervation occurs in *A. serrata* and sometimes in *A. spathulata*. It is probable that *A. quinquealata* represents a true *Abelia* with five wings (§ *Serratae* and § *Rupestris*).

V.17615 Holotype, figured Pl. VIII, fig. 32, is an almost perfect impression of the upper surface and apical disc. The counterpart shows three wings (lower surface).

V.17616 Figured Pl. VIII, fig. 33, text-fig. 12*a*, shows three complete wings and parts of two others (lower surface), also the apex of the fruit. The counterpart shows the apical disc and rim, as described, and the impressions of the wings (upper surface).

V.18096 Shows two wings and half of a third.

Abelia trialata n. sp.

Plate IX, figs. 1-3; text-fig. 13.

DIAGNOSIS: Fruit large, oval, flattened, obscurely ribbed above. Wings three, very large, with a median nerve, and a pair of lateral nerves reaching half the length of the wing, also secondary nerves, nervation reaching the margin.

HOLOTYPE: V.17617.

DESCRIPTION: Fruit inferior, elongate-oval, or markedly narrowed at the apex, flattened, obscurely ribbed above; apical disc with a central boss, but no marginal rim (text-fig. 13); surface of the fruit showing small, irregular, polygonal cells (V.17617), except along the two margins and around the apex, where the cells are oblong and aligned in longitudinal rows. Calyx accrescent, but prolonged beyond the apex of the fruit into a whorl of three large, sub-equal wings. Wings free from the base, each with a prominent midrib extending to its apex, flanked by two sub-parallel ribs which extend for half or two-thirds the length of the wing; secondary nerves arise at angles varying from 50° to 60°; the nervation is continued to the margin, and is more prominent on the upper than on the lower surface (text-fig. 13*a*). The wings are convex on the upper and concave on the lower surface in transverse section. Length of fruit 11 mm.; breadth 4 mm.; length of wings 15-17 mm., possibly greater; breadth 3.5-7 mm.

Impressions only. Those of the lower surface of a detached whorl of bracts show a characteristic, triangular, median area, with a hollow opposite each wing; three spoke-like ridges arising

from a central boss alternate with these hollows (Pl. IX, fig. 3; text-fig. 13c).

Impressions of the upper surface of a whorl show the apical disc of the fruit (Pl. IX, fig. 2; text-fig. 13b).

AFFINITIES: This fossil shows the characters of *Abelia*, although it is larger than any living species. *A. corymbosa*, Regel & Schmalhausen, *A. insularis* Nakai, *A. Zanderi* (Graebner), and *A. umbellata* (Graebner & Buchwald) have similar, but smaller, broad bodies (*A. corymbosa*, length 6 mm., breadth 2 mm.; *A. insularis*, length 9 mm., breadth 2.25 mm.).

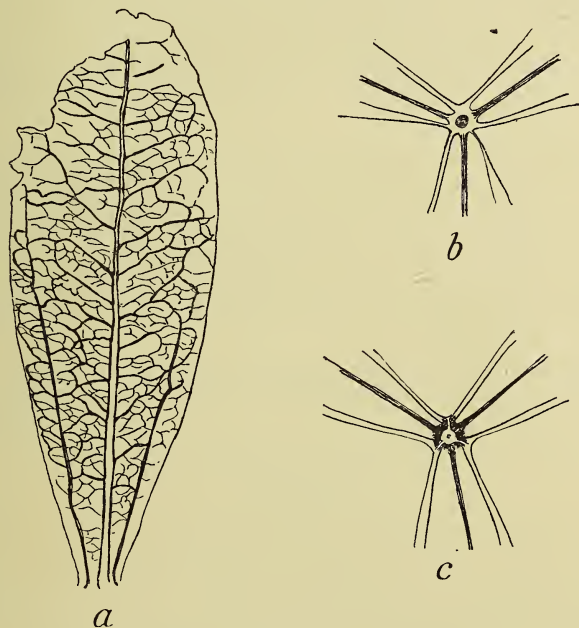


FIG. 13.—*Abelia trialata* n. sp. *a*, Camera lucida drawing of a wing showing details of nervation; V.17618, $\times 4$. *b*, Diagrammatic drawing of apical disc of fruit as seen on an impression of the upper surface of the wings. *c*, Diagrammatic drawing of the median area as seen on an impression of the lower surface of the wings (counterpart of *b*).

The cell-structure of the fruit of *A. corymbosa* agrees with that of the fossil. The largest wing we have found among living species (*A. corymbosa*) is 14 mm. long, but relatively broader. The nervation of the fossil resembles that of various species, and *A. corymbosa* has nerves more prominent on the upper than on the under surface of the wings. The three-winged character would appear at first sight to exclude the fossil from the genus *Abelia*, but we have found three-winged fruits (Pl. IX, fig. 5)

fairly common on bushes of *A. Graebneriana* Rehder in Kew Gardens, both in 1924 and 1925; this species normally has two wings. The evidence therefore associates the fossil with *Abelia*, and especially with *A. corymbosa* (Pl. IX, fig. 4).

A. trialata bears a striking resemblance to *Heterocalyx Ungerii* Saporta (Saporta 1873, p. 111, pl. xvi, figs. 19-26), which is referred to Anacardiaceae. Saporta describes the fruit as superior, and figures a specimen with a slender stalk. His description is insufficient to permit of detailed comparison. We have never seen any indication of a stalk in the Bembridge material, from which we infer that the fruits are inferior; moreover the angle of emergence of the wings supports this view (Pl. IX, fig. 1).

Professor Laurent also figures and describes *Heterocalyx* from Célas (Laurent 1899, p. 134, pl. xiv, fig. 6), and states that it may have either three or five wings. His figure shows no stalk or fruit.

- V.17617 Holotype, figured Pl. IX, fig. 1. The impressions of two fruits each with two wings; the third wing in the upper specimen has come away on the counterpart (now lost), and in the lower specimen appears to be buried in the stone.
- V.17618 Figured Pl. IX, fig. 2, text-fig. 13a. Impression of parts of three wings (one almost complete), with counterpart.
- V.17619 Figured Pl. IX, fig. 3; impression of three wings (one complete), lower surface.
- V.18097 Body and two wings.
- V.18098 One perfect wing and parts of two others.
- V.18099-18100 Two specimens with counterparts showing one imperfect wing on each.
- V.18101-07 Seven specimens showing fragmentary wings.

Abelia sp. 4

Plate IX, fig. 6; text-fig. 14.

DESCRIPTION: Actual fruit unknown. Wings four, lanceolate-obovate, with a broad prominent mid-rib and two obscure, short, lateral nerves sub-parallel with the mid-rib (text-fig. 14a).

Cell-structure (which can only be seen with difficulty in a few places) of small, irregularly arranged, polygonal cells. Length of wing (almost perfect) 15 mm.; breadth 3 mm.

AFFINITIES: The wings recall *Abelia* in form and nervation and are somewhat similar to those of *A. trialata*. Nevertheless, it is improbable that this specimen is a four-winged example of *A. trialata*, as it differs in its narrower, relatively longer wings with obscure lateral nerves instead of conspicuous ones; we have not found such marked differences combined in any one living species. As there is only one imperfect specimen, we have given no specific name.

- V.17620 Figured Pl. IX, fig. 6, text-fig. 14a, is an impression of the

lower surface of a whorl of wings. One wing is almost perfect, and there are parts of three others. The central area, as seen in the impression, has a hollow opposite each wing and a median boss (text-fig. 14*b*).

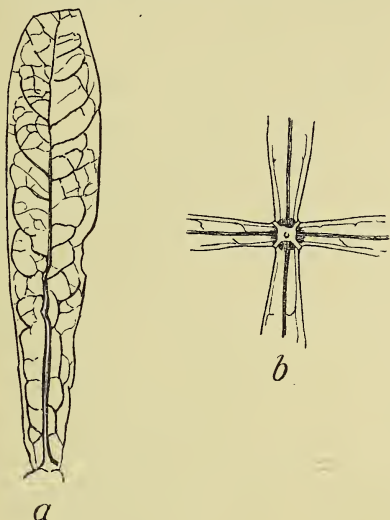


FIG. 14.—*Abelia* sp. 4. *a*, Camera lucida drawing of one wing to show nervation. Specimen V.17620, $\times 4$. *b*, Impression of the lower surface of the wings (diagrammatic).

Genus *DIPELTA* Maximovicz

1877 *Bull. Acad. St. Pétersbourg*, xxiv, p. 50.

Dipelta europaea n. sp.

Plate IX, figs. 7-9.

DIAGNOSIS: Fruit inferior, small for *Dipelta*, cylindrical, pedicellate, enclosed by three bracts with entire margins conspicuously and coarsely net-veined; two bracts large, rounded, and wing-like; one small and sub-triangular.

HOLOTYPE: V.17621.

DESCRIPTION: The fruit, which has a long slender pedicel, lies between three bracts which completely envelop it. Two of these are large, wing-like and symmetrical, with entire margins. They are united to the fruit sub-marginally at about one-fourth of the length from the base of each wing. The nervation is conspicuous, prominent on both surfaces, and, diverging from the point of attachment of the fruit, gives rise to a coarse network over the whole surface. The third bract, small, rounded-triangular with entire margin, is joined to the fruit by the basal edge. It has a

midrib which may or may not merge above into the net-veining. The fruit is inferior, small, cylindrical, with a dome-shaped apex and a few longitudinal ribs ; in the sulci between the ribs large scattered tubercles (? hair-bases) occur. One specimen (Pl. IX, fig. 7) shows the impression of floral organs or sepals above the fruit, but they are too indefinite for description. Breadth across the complete fruit 8 to 9.5 mm. ; length of large bracts about 9 mm. ; length of triangular bract 6 mm. ; breadth of triangular bract at the base, about 5 mm.

Impressions, including some counterparts.

AFFINITIES : This beautiful fruit is undoubtedly a species of *Dipelta*. The living genus is represented by four species, all with similar fruits enveloped by bracts. Two bracts are always large and wing-like as described above, one is small, ovate or rounded triangular, and there is sometimes a minute ligulate bract lying between the two large ones and completely concealed by them. None of the fossils is so placed as to show this small bract, if it be present. In all the living species the margins of the bracts are entire, the nervation is conspicuous and prominent on both surfaces, the main nerves diverge from the point of attachment of the fruit and quickly give rise to coarse net-veining all over the surface. The fruit is inferior, ovate, ribbed or angled with a few coarse hairs which arise from similar prominences to those seen in the fossil. It is crowned above by the long, persistent sepals. In all species the fruit and pedicel are attached to the base of the small bract, but the connexion with the large bracts varies from peltate in *D. floribunda* and *D. elegans*, through submarginal in *D. yunnanensis*, to marginal in *D. ventricosa*.

Of the four species, *D. yunnanensis* most resembles the fossil (breadth across complete fruit 12.5 mm. ; length of large bracts 11 mm. ; length of small ovate bract 7.5 mm. ; breadth 6 mm.). All other species are considerably larger, with a relatively smaller triangular bract. The nervation of this species is very similar to that of the fossil, and is of about the same degree of coarseness ; the small triangular wing has a mid-rib.

All species of *Dipelta* are shrubs indigenous to China. *D. elegans* Batalin inhabits north-western China (Kansu), *D. floribunda* Maxim. occurs in thickets on the mountains of Yunnan and is also recorded from Hupeh. *D. yunnanensis* Franchet (1891), first discovered by the Abbé Delavay, was found later by Wilson growing on cliffs at 8,500 ft. in western China, by Forrest amongst scrub and pine-forests in the Lichiang Range between 9,000 and 11,000 ft., and by Schneider in the same range at 3,500 ft. *D. ventricosa* Hemsl. is recorded from Yunnan up to 10,000 ft.

V.17621 Holotype, figured Pl. IX, figs. 7, 8. Impression of fruit showing also three bracts. Fig. 7 shows the fruit, fig. 8 (counterpart) shows the impression of small triangular bract.

- V.17622 Figured Pl. IX, fig. 9. Impression of fruit (hollow-mould) with two large bracts and pedicel.
 V.18108 Impression of two large bracts with the hollow for the fruit.
 V.18109 Impression of small triangular bract and part of a large bract.
 V.18110 Impression of part of large bract and of fruit with pedicel.

Family COMPOSITAE ?

Genus ?

Plate IX, fig. 11.

Fruit cylindrical, strongly ribbed (as seen in section at the apex), contracted somewhat at each end, and with the impression of a pappus at the upper end. Length (imperfect at base) without pappus 3.6 mm.; breadth 1 mm.; length of pappus 4.3 mm.

The specimen is too imperfect and poorly preserved to admit of definite determination, but it may be the fruit of a Compositae.

- V.17623 Figured Pl. IX, fig. 11. Impression of fruit with some organic matter remaining, and hollow impression of a tuft of hairs.

Family ?

Genus FLABELLICULA nov.

Flabelllicula anglica n. sp.

Plate IX, figs. 12, 13.

DIAGNOSIS of genus and species: Fruit inferior, oval-oblong, flat, smooth except for a few low longitudinal ribs, with a fan-like wing arising from the whole apex; wing fairly thick below, but thin at the wavy margin; nerves robust, branching, curvilinear.

REMARKS: There is nothing to add to the description of this beautiful little fruit given in the diagnosis, except that the nerves fan out from the base, and then branch irregularly, usually pinnately. The ultimate nervation forms fairly large polygonal closed areas.

Length of fruit incomplete; breadth 0.5 mm.; radius of wing 3.5 mm.; spread of wing 5.5 mm.

The impressions of two fruits.

We have been unable to trace the systematic position of this fruit. The inferior winged fruit suggests the orders Rubiales or Asterales; more probably the former.

- V.17624 Holotype, figured Pl. IX, fig. 12. Impression of fruit with almost perfect wing.
 V.17625 Figured Pl. IX, fig. 13. Impression with a little organic substance. The fruit is broken at the base.

Genus *SAMARAVECTIS* nov.*Samaravectis ovalis* n. sp.

Plate IX, figs. 14-16.

DIAGNOSIS of genus and species: Fruit oval, thin, flat, stipitate, winged, symmetric or asymmetric; body of fruit oval, flatly convex; wing surrounding the fruit except at the base, not cleft at the apex, strongly margined, either rounding into the pedicel above the base, or merging gradually into it, obliquely striate; style apical.

HOLOTYPE: V.17626.

DESCRIPTION: The six specimens of this fruit show that it may vary considerably in shape and symmetry, but they show certain characters which unite them: the central nut rather clearly delimited from the wings, and the striations over the wings, which are formed of rather large elongate cells with sinuous outlines. The nut is represented in one specimen (fig. 16) by an internal cast, whether of locule or of seed we cannot say. Its surface is finely pitted. There is no evidence to show whether the seed was anatropous or orthotropous. Length of fruit 6 mm.; breadth 3.5 mm.

AFFINITIES: We compared this fruit with various forms of Polygonaceae, Ulmaceae, and Urticaceae, all of which, although they show certain features in common, yet differ so materially that we cannot assign the fossil to any of these families. In all we find samaras with this form of wing and nut.

In Polygonaceae the two genera which most approximate to the fossil are *Rheum* and *Polygonum* (*P. dumetorum*). The striation of the wings is like, but the fruits have a persistent inferior calyx, and the nut of *Rheum* is triangular.

In *Ulmus*, which again resembles the fossil in form, the winged fruit is cleft at the apex, the nerves are strong, markedly asymmetric, and reticulate, also there is a persistent calyx.

In Urticaceae, *Boehmeria* most nearly approaches the fossil. Its small samaras are of the same form, strongly margined, striate, and the nut is comparable in character. But the fruits are so much smaller, and so strongly hairy, as completely to outweigh any correspondences. We therefore cannot place the fossil, but as it is so well characterised and well represented we have given it a generic and specific name:

V.17626 Figured Pl. IX, fig. 14. Impression of winged fruit showing the wings merging into the stalk.

V.17627 Figured Pl. IX, fig. 15. Impression of the winged fruit showing cell structure of wings. There is a second specimen on the same stone.

V.17628 Figured Pl. IX, fig. 16. Impression of fruit (part of the wing broken) showing cast of locule.

V.18111-12 Two specimens showing imperfect impressions of fruits.

Genus **CARPOLITHUS** Linnaeus

1768 Syst. Nat. ed. 12, iii, p. 172.

Carpolithus actinidiformis n. sp.

Plate IX, fig. 17.

DIAGNOSIS : Seed ovoid, truncate at one end where is a large cup-shaped depression (the hilum ?) from which a bundle of fibres passes longitudinally in the thickness of the testa ; testa hard, thick, crustaceous, deeply pitted with conspicuous hexagonal pits, which become elongate longitudinally round the apex.

HOLOTYPE : V.17629.

DESCRIPTION : The seed is split longitudinally along the line of fibres described above. These, therefore, probably represent the raphe. Anatropous seeds frequently split in this manner as the result of germination (or fossilisation). We were unable to find the micropyle.

Length 2 mm. ; breadth 1 mm.

AFFINITIES : The size, form, external pitting, and terminal depression (hilum ?) recall *Actinidia*, but we could not make certain of the anatropous form of the seed, and the character of the testa is not altogether like it, as it does not show the very characteristic nodular inner surface generally seen in *Actinidia*, as though the pits had been punched through from the outside ; also, to be crushed as it is, it must have been more globular than any living *Actinidia*. We cannot, therefore, refer it to the genus, nor even to the family Ternstroemiaceae with any confidence. We have, however, drawn attention to the resemblance to *Actinidia* in its specific name. It is quite possible that further and better material may throw light on its affinities.

V.17629 Figured Pl. IX, fig. 17. Seed partly carbonised, partly represented by a cast.

V.18113 Impression of seed showing the pits as swellings.

V.18114 Doubtful carbonised specimen.

Carpolithus sp. 2

Plate IX, fig. 18.

A large fruit showing the following characters : (1) An extremely thin brown outer coat (probably the epicarp) which is adherent to a layer of matrix impregnated with carbonaceous matter (the decayed mesocarp ? possibly fleshy). (2) A thick, hard, dark-brown, bony endocarp formed of close parenchymatous tissue. (3) Within this is an internal cast of either the endocarp or seed, which shows a coarse network of fibres. At the base, on either side, is a ridge on this internal cast. These ridges must represent canals in the wall of the endocarp ; and from them, and

from a differentiated area lying between them at the base, to which part of the substance of the seed or endocarp still adheres, the fibres radiate, anastomosing in the upper part of the nut. The cells over the differentiated area are quadrangular, aligned transversely.

Length 11.5 mm. ; breadth 11 mm.

The form of the endocarp lying on a flat hollow side filled with matrix shows that it must have been a stone which split into symmetrical halves in the manner of a plum-stone ; but the pair of canals, and the nervation of the interior show that it cannot belong to § Prunoideae of the family Rosaceae. It is possible that it may belong to Icacinaceae, but the evidence is insufficient for more than a surmise.

V.17630 .Figured Pl. IX, fig. 18. The specimen described above.

V.18115 Cast of the exterior of a fruit, and counterpart, with remains of the endocarp ; it may belong to this species.

Carpolithus sp. 3

Plate IX, figs. 19-22.

The description of this very characteristic species is based on the assumption that it represents the whole, or part, of a multi-locular fruit ; but we have found no living material to aid us in its interpretation. The parts seem clear, but the structure is unlike that of any fruit we know. We can find none with locules in series, as appears to be the arrangement in this fossil.

This fruit is represented by two specimens. One of these (fig. 19) shows an external impression of the fruit, with the internal casts of a row of locules to which the remains of the carpels cling. The continuity of the internal casts with the matrix at the flat back and at the base, shows that they must here have had openings which admitted sediment. The cast of each locule, at its most elevated point, shows a papilla which must mark the entrance of the vascular canal. The other specimen (fig. 20) shows the impression of a fruit, in which lay originally the two carpels (organic) which were detached and photographed both front (fig. 21) and back (fig. 22). These two carpels are fused together, so that the whole series of carpels must have been fused, as suggested by the specimen seen in fig. 19. The organic remains of both specimens show the same rather large-celled parenchyma, and the structure of the carpels seen in figs. 21 and 22 agrees with that seen in the casts in fig. 19. Each carpel is semi-obovoid, the anterior surface being convex, the posterior flat. Each dehisces by a longitudinal slit along the dorsal margin (the left of each carpel in fig. 22), and each has a large round aperture at the base. It is through these two apertures that the sediment has entered, as seen in fig. 19. Doubtless the one is associated with the nutrient

fibres, and the other with the style, but we have failed to recognise exactly how.

We are at an entire loss to explain the occurrence of a linear series of carpels enclosed in a single envelope. On the other hand, it is equally impossible to explain this as a single locule containing a row of seeds, for we know of no seeds which are fused to form a single mass, opening for germination by a series of valves, as seen in these specimens.

V.17631 Figured Pl. IX, fig. 19. The external impression of the fruit with the casts of a linear row of locules.

V.17632 Figured Pl. IX, figs. 20-22. The impression of a fruit, originally containing the two organic locules figured (figs. 21, 22).

Carpolithus sp. 4

Plate IX, fig. 23.

A large fruit or seed represented by counterparts, which show an impression with remains of carbonised substance; obovoid, truncate at the base, where there is a large aperture, thick walled. The specimen appears to have been bitten at the apex, and part of the seed eaten, for into the cavity that might have been formed in this manner sediment has entered. The interior of the walls in the lower part shows an alternation of substance and matrix, which may be the evidence of the testa projecting into a ruminant albumen as in seeds of Anonaceae, many of which are the size and shape of the fossil, though the remains of the specimen are too badly preserved to speak with any certainty as to its probable affinity.

Length 7 mm.; breadth 3.5 mm.

V.17633 Figured Pl. IX, fig. 23. Impression of fruit as described. The dark patch to the left of the figure is due to a shadow of the rock.

Carpolithus sp. 5

Plate IX, fig. 24.

The complete impression, represented by counterparts, of an obovoid fruit, lobed at the apex (see fig.). Surrounding it are the impressions of floral organs, occurring as a series of holes with linear scars between these and the fruit. These would appear to be the remains of the sepals and petals. We have been unable to determine the number of lobes, but it is more than four.

Diameter of fruit 4 mm.

V.17634 Specimen as described above.

Carpolithus sp. 6

Plate IX, figs. 25, 26.

Fruit ovoid, one-loculed, with thick woody walls ; epicarp black and rugose (represented by a few fragments only) ; endocarp, brown, thick, and woody, formed of parenchymatous tissue, with a large funnel-shaped aperture at one end tapering into a narrow canal which leads into the locule ; interior of locule longitudinally rugose. The aperture probably indicates the base of the fruit where the vascular bundles entered. The seed or seeds would appear to have been erect. In the figure the fruit is inverted in order the better to show the canal.

Length 3.5 mm. ; breadth 2.1 mm.

V.17635 Figured and described above. The specimen is the carbonised endocarp freed from the matrix.

Carpolithus sp. 7

Plate IX, fig. 27.

The specimen shows the impression of an expanded infundibular calyx. The calyx is frill-like, expanded on many long radiating awns which project beyond it, one being shredded at its extremity into two tips, either accidentally or through branching. The calyx is hyaline in its upper part, but ribbed and striate below. Within this frill is the impression of the basal part of an inner ribbed ob-conical structure, which probably represents the impression of the base of the fruit. The cavity between this and the calyx was filled by sediment.

Diameter of frill 3.5 mm. Length of longest awn 3 mm.

We are unable to place this specimen with any certainty. The difficulty is to find any fruit with such numerous awns to a frilled calyx. Some of the Valerianaceae have the awns united to form a funnel at the apex of the fruit, and this easily breaks away from the heavy fruit ; but so far as our observation goes these awns are always feathered. The calyx of Dipsaceae frequently shows a hyaline frill stretched on numerous long awns which may extend much beyond the frill as in the fossil. In the absence of any evidence as to the nature of the fruit itself, we cannot refer it with any confidence to this family.

V.17636 Figured Pl. IX, fig. 27. The impression of a calyx described above. There is a good impression of *Engelhardtia* on the same stone.

Carpolithus sp. 8

Plate IX, fig. 28.

This specimen shows the impression, with a little substance remaining, of a minute infundibular calyx, with sepals produced into long awns; and possibly the remains of part of the fruit. The conical upper portion of the impression is seen to be at a higher level than the ribbed part below, which implies that this part of the specimen lay within the calyx; consequently that it was either the fruit itself, or parts of the floral organs, or the impression of a central mass of hairs such as closes the calyx of some Labiatae. It shows two symmetrically placed, thin, lateral awns bent inwards and a conical tuft in the middle. Below this are seen the ribs of the calyx, and on either side the awned sepals.

Length to tip of awn 2 mm.; breadth across top of calyx 1 mm.

The character of the calyx suggests that it may be that of a small Labiate, but the evidence is too obscure to be worthy of more than a suggestion.

V.17637 Figured Pl. IX, fig. 28. Impression as described above.

Carpolithus sp. 9

Plate IX, figs. 29-31.

Two carbonised endocarps of a sub-globose, one-loculed fruit, rugose externally and having a deep depression at one end and a central scar at the other. The depression and scar are each surrounded by a quadrilateral area with sides convex towards the centre; the angles of the two areas agree in position. The large depression leads to a central canal which can be seen on the broken specimen (fig. 31) to lead into the small central cavity through the very thick wall. Surrounding this canal are four symmetrically placed, very small canals, of which the external openings can be seen (not very clearly) close to the central canal in fig. 29. Fig. 31 shows one of these in section (dark line) to the right of the central canal. The quadrilateral area at the apex, produced sharply at the angles, can be seen in fig. 30.

Length 4 mm.; diameter 3 mm.

We can make no suggestion as to the systematic position of this species.

V.17638 Figured Pl. IX, figs. 29, 30. An endocarp removed from the stone.

V.17639 Figured Pl. IX, fig. 31. A broken endocarp removed from a broken impression. It shows the interior of the locule.

Carpolithus sp. 10

Plate X, figs. 1, 2.

The counterpart casts, with some substance remaining, of a small, four-lobed globular fruit. Each lobe has a median longitudinal groove, or line of dehiscence, extending from base to apex. One end shows a circular area (of attachment ?); the other is deeply sunk.

Diameter 2 mm.

The fruit would appear to have been a capsule, with either loculicidal or septicidal dehiscence. It is surrounded by a stained area such as sometimes is seen round these Bembridge fossils. This appears to have no organic significance.

V.17640 Figured Pl. X, figs. 1, 2. Counterparts, showing the external impression of a fruit.

Carpolithus sp. 11

Plate X, figs. 3, 4.

Two counterparts show impressions, with some substance remaining, of two stipitate leaf-like bracts with very well-marked midribs and pinnate secondary nerves which branch and anastomose in a complicated manner. Within the bracts lies the impression of a fruit placed somewhat excentrically. The margins of the bracts are torn away except in a second specimen, V.18116, where the entire margin remains near the base.

Careful camera-lucida drawings showed very clearly that when superposed neither the midrib nor the nervation of the counterparts could be made to coincide. The necessary inference is that the specimen represents two superimposed bracts, not one. This inference is confirmed by the microscopical examination which shows on each counterpart the remains of two sets of nerves at different levels, which together give rise to the extremely complicated network seen in the figures. It was only possible to disentangle these two layers here and there where the actual fibres were preserved. The secondary nerves branch from the midrib in a slight curve, convex upwards, at angles of 90° in the lower third of the bract, the angles diminishing to 30° at the apex. These nerves branch or bifurcate two or three times at angles of about 40° , after which they anastomose, forming a series of lenticular areas towards the margin; these areas being again subdivided to form a rather coarse network.

The dark blotch (fig. 3) corresponds with a sunken area on the counterpart (fig. 4). It must represent the impression of a fruit which lay between the bracts, and was possibly attached at the point one-third from the base, where the midrib is seen suddenly

to narrow (fig. 3), and which is also marked by a change in the direction of the secondary nerves. Over this sunken area are seen the remains of fine long fibres, sometimes crossing one another, which appear to be the remains of the epicarp.

Length (imperfect) 20 mm. ; breadth (imperfect) 15 mm.

We interpret this most interesting fossil as a fruit borne between two bracts, such as occurs in the genus *Linostoma* (Thymeliaceae). In this genus the bracts are closely appressed so as to coincide more or less in position, though they are not always of the same size. The fruit may lie, either wholly between the bracts, or projecting above them, according as it is sessile (attached to one bract) or stipitate. This is the only genus we have found which offers any satisfactory explanation of the fossil, although the remains of the epicarp, if such they be, do not agree with those of *Linostoma*.

Fruits of this size, and of much this form, with a similar type of nervation, are described and figured from St. Zacharie and Armissan by Saporta (1865, pl. ix, fig. 13) as *Dodonaeites Decaisnei* Sap. He suggests that they are related to *Dodonaea*, but, at the same time, points out certain great difficulties in the ascription ; difficulties which, in our opinion, judging by his figures and illustrations, are insuperable. Certainly our fossil cannot be related to *Dodonaea* ; for though the nervation is somewhat similar, *Dodonaea* has no midrib from which nerves are given off, but two flattened valves attached by their straight margins. At maturity these valves split away from a central carpophore.

We also compared the specimen with fruiting bracts of *Dobinea*, *Bougainvillea*, and *Neuropeltis*, but in all the nervation is quite dissimilar, and there is only one bract to each fruit. Dr. Hollick (1923), in his study of *Carpolithes Alleni* (Lesq.) Cockerell, gives good illustrations of that fossil. Its size and shape are somewhat similar to the Bembridge fossil, but the anastomosing nervation without definite secondary nerves is different. He compares this species, but does not identify it, with *Koelreuteria*. The Bembridge fossil is not comparable with *Koelreuteria*.

V.17021 Figured Pl. X, figs. 3, 4. Impressions (counterparts) of bracts with some of the substance.

V.18116 Impression of bract.

Carpolithus sp. 12

Plate X, fig. 5.

The specimen is represented by counterparts which show the impression, with some carbonised remains, of a stiff, flabellate wing of a fruit, or a leaf. It is broken at the base. The "wing" is more than semicircular, with an entire slightly wavy margin, thick and coriaceous, with fine stiff nerves which bifurcate at curved angles to form a rather conspicuous series of close branches.

Radius 7 mm.

In the absence of the base we are uncertain what this specimen may represent : the wing of a fruit such as is seen in *Malpighiaceae*, a stiff flabellate leaf such as that of *Ginkgo*, or a fern.

V.17641 Figured Pl. X, fig. 5. Impression of wing of fruit or of a leaf.

Carpolithus sp. 13

Plate X, fig. 6.

The specimen shows the impression of the inner surface of the valve of a fruit. It has a thin midrib from which delicate filiform nerves are given off at angles of about 45°. These repeatedly branch dichotomously in an irregular manner and anastomose to form a coarse network of oblique loops over the surface. Covering the nerves are the remains of a membranous skin with a surface finely striate, the striations running obliquely from the midrib as in the inner lining of many pods and capsules. This nervation can only be seen when the specimen is highly varnished.

Length 18 mm. ; breadth 13 mm.

The specimen is too poor to attempt determination.

V.17642 Figured Pl. X, fig. 6. The impression of the interior of a pod.

Carpolithus sp. 14

Plate X, fig. 7.

(Scattered specimens also seen in figs. 8, 9.)

Fruits solitary or in groups, on long slender stalks. Segments of calyx or perianth produced into teeth. Length of fruit including pedicel 4.5 mm.

Nutlets free, sometimes as many as four in a fruit, basally attached, obovoid or oblong (usually much distorted), slightly angled on the ventral face, with a corky mesocarp which seems once to have enveloped the whole nut, as remains of it are found in every part of the endocarp. Endocarp hard, woody, with fairly thick, dark-brown walls ; surface finely pitted, with pits a little longer than broad, aligned irregularly in longitudinal rows.

Length of nutlet including corky covering at the apex 0.75 mm. ; breadth 0.4.

The nutlet figured was removed with several others (all distorted) from the matrix. Originally it was perfect, but was broken during photography. Fruits and nuts are preserved in blocks of soft white marl, containing impressions of *Dicotylophyllum pinnatifidum*, which belong to the Sedgwick Museum, Cambridge. The association of these two sets of fossils may point to their being fruits and leaves of the same species. In a few instances (fig. 8) the slender pedicels seem to pass either into or behind the

leaf. But probably the association is accidental, as it is difficult to understand any association of fruits with leaves in the apparent manner of the fossils. If so, it is the consequence of a common habitat, which has resulted in their being entangled and swept together into the water.

The arrangement of the nutlets, their basal attachment, and the character of mesocarp and endocarp, suggest a possible relationship to *Lycopus*; but they have not the defined and margined attachment area seen in *Lycopus*, and the fruits of this genus are not stipitate. We must therefore leave the relationship as unknown.

Judging by the way in which the nuts have remained grouped, and by the distortion they have almost always undergone, it would appear that they may have been carried into the water before they were ripe.

The only specimens seen were on blocks of white marl from the Sedgwick Museum, Cambridge.

Genus **DICOTYLOPHYLLUM** Saporta em. Bandulska

1894 Saporta, Fl. Foss. Portugal, p. 147.

1923 Bandulska, *Journ. Linn. Soc. Bot.*, xlv, p. 244.

[This form genus is used by Dr. Bandulska to include any fossil dicotyledonous leaves of doubtful affinity; Saporta restricted it to primordial dicotyledons only.]

Dicotylophyllum pinnatifidum n. sp.

Plate X, figs. 8-12.

DIAGNOSIS: Leaves (always incomplete at the base) long-linear, attenuated above and below, markedly pinnatifid with segments either opposite or alternate; segments roundly quadrilateral, with a hyaline rim sometimes recurved. Nervation somewhat variable; one secondary nerve in each segment runs towards the apex of the segment and throws off a branch directed backward towards the sinus immediately below; sometimes there are a few intermediate secondary nerves.

HOLOTYPE: In Sedgwick Museum (Pl. X, fig. 8).

DESCRIPTION: The leaves of this species are always incomplete, the base not having been preserved. They appear to have drifted before fossilisation.

Leaves coriaceous, long-linear, gradually tapering above and below, pinnatifid, with segments either opposite or alternate on the same leaf; segments roundly quadrilateral, with a slight superficial prominence at the cusp and a puckering at the sinus, an entire margin, and a definite hyaline rim. The nervation is somewhat variable; prominent on the lower, and sunk on the upper surface; in each segment there is usually a secondary nerve arising from

the midrib at a wide angle and running to the apex of the segment ; it gives off a reflex branch passing towards, but not into, the sinus below. There may also be short intermediate nerves between the secondaries, given off from the midrib at wider angles. The tertiary nervation can only be seen in the lower part of the leaf, and consequently causes the nervation of this part to appear more complicated. The cuticle of the upper surface shows polygonal cells (fig. 12) ; the nerve fibres have either spiral or annular thickening, we are uncertain which.

Width from 0·75 mm. to 5 mm. The most usual width is about 3 mm. The longest fragment measures 35 mm.

The leaves are preserved either as impressions (both the upper and lower surfaces are so preserved), or as carbonised, and sometimes highly pyritised, remains. They appear to be of different textures, as noted by Gardner (1888, p. 419). Some are thick, black, and coriaceous with recurved margins, but rarely showing a hyaline border, and with markedly convex areas on the upper surface between the conspicuous nerves. These leaves sometimes present a false appearance of dissected and overlapping pinnules (upper part of fig. 9) owing to abrasion. Other leaves are thin, flat, light brown, with hyaline margins, and only the main nerves show. We agree with Gardner that the two types represent but one species, because we have found both on the same leaf.

AFFINITIES : The determination of the species presents the greatest difficulty. Fossil leaves closely resembling these in form, but with different nervation, if one may judge by figures and descriptions, have been referred by various authors to *Myrica*, *Banksia*, and *Dryandra* among Dicotyledons, and *Gleichenia* among Cryptogams. Gardner in the first instance (1886a, pp. 402, 403, pl. iii, figs. 1-4) referred the Bembridge species to *Gleichenia* ; but after obtaining better material, recognised the nervation as dicotyledonous (1888, p. 419). In the Survey Memoir (1889, p. 183), in the list of Bembridge species revised by Gardner, both *Myrica* sp. and *Gleichenia* sp. are recorded. We consider that only one genus and one species is represented.

In view of the various genera to which similar species have been referred we examined *Banksia*, *Grevillea*, *Dryandra*, *Myrica*, and *Gleichenia*, also Podostemaceae, Selaginellaceae, and Jungermanniaceae. Nervation and leaf-arrangement exclude the last three families. Cuticular structure excludes *Gleichenia*. Of the others *Banksia* and *Myrica* alone have any resemblance.

In *Banksia*, although some species have pinnatifid leaves, none are like those of the fossil. *B. serrata* is perhaps nearest, but the leaves are larger, more oval, flat, and more coriaceous. It has a definite smooth margin, but this is thick, not hyaline. The secondary nerves give off branches, some of which are directed to the sinus, but otherwise the nervation is different. The lower side of the leaf is pubescent. But more than this ; the habitat of

Banksia would seem entirely to forbid the possibility of any member of the genus growing in such a position with regard to water that its leaves could be swept into it in the masses which are one of the distinguishing features of this species. Gardner (1888, p. 419) states: "We came upon a patch about 30 yards long and 3 or 4 yards wide, almost made up, to a depth of nearly 6 inches, of the detached leaves of a finely cut *Myrica*."

This extraordinary abundance is of the highest importance in seeking to determine this plant. It is an abundance equalling or even exceeding that of the remains of *Typha*, *Phragmites*, *Limnocarpus*, and *Brasenia*, and would seem to indicate that the plant had an aquatic or riparian habitat.

The genus *Myrica* would permit of such a habitat, and in this respect is superior to *Banksia*. The leaves of *M. asplenifolia* are smaller, thinner, more deeply segmented than those of *Banksia*, and in these features more closely resemble the fossil; also they show the cusp and the puckering at the sinus. The nervation, however, is quite unlike that seen in the fossil. There are three sub-parallel nerves to each lobe, one short nerve running to the sinus, two longer ones curving upward near the margin; there is no backward-directed branch, and the tertiary nervation is much more complicated than in the fossil. There is no hyaline margin to the segments.

The fossil species which most resembles the Bembridge species is *Myrica* (*Comptonia*) *dryandraefolia* (Brongniart 1828a, p. 49, pl. iii, fig. 7). Ettingshausen (1853, p. 55, pl. xix, figs. 1-26) and Heer (1856, II, p. 96, pl. xcvi, fig. 20) refer this species to *Dryandra*. Laurent (1899, p. 76, pl. iv, figs. 9-14), following Brongniart and Saporta (1865, p. 94, pl. v, fig. 8), calls it a *Myrica* although he expresses a doubt as to the correctness of the ascription. The species is always represented with from two to four parallel, unbranched, stiff nerves; a type of nervation which we have never seen in the Bembridge specimens. Apart from a general resemblance, the chief character in common with the Bembridge species is its great abundance. Professor Laurent remarks of it (*loc. cit.*): "Par son abondance dans les dépôts tertiaires inférieurs et moyens aussi bien que par sa forme, cette curieuse plante, quelle que soit d'ailleurs l'interprétation qu'on adopte, est une des plus caractéristiques de la période oligocène."

In our own opinion it is among aquatic herbs, or riparian herbs or bushes, that the alliance must be sought.

V.17643 Figured Pl. X, fig. 10. Impression of under surface of leaf.

V.17644a Cuticle figured Pl. X, fig. 12, from stone V.17644.

V.17688 Figured by Gardner (1886a, pl. iii, fig. 3) and described by him as a dicotyledonous leaf.

V.18117-19 Three fragments showing nervation.

V.18120-24 Five sets of counterparts of leaf-fragments.

V.18125-49 Twenty-five rock specimens with fragmentary impressions,

some of upper, some of lower surface. Numerous fragments were not catalogued.

Dicotylophyllum sp. 2

Plate X, figs, 13, 14.

Two counterparts, one only showing the base. The specimen without base is labelled "*Rhus*" in two places, both in pencil. The genus is included in Starkie Gardner's list (1888, p. 419) among those identified by himself and Saporta. The other was not labelled in any way, except with a number by Mr. Hooley. It was not among those specimens which came to us with an old label accompanying them stating that they were "*Fossil leaves named by the Marquis de Saporta and J. S. Gardner, Esq., F.G.S.*" There seems no evidence therefore that the two specimens had ever been associated in A'Court Smith's collection as parts of the same leaf, or, consequently, that Saporta and Gardner, when naming *Rhus*, saw the base of the leaf.

DESCRIPTION : Taken together, the specimens show the following features :

Leaf (or leaflet) small, lanceolate, coarsely and irregularly toothed, sessile, lamina gradually narrowed to the base of the leaf to form narrow flanges broader on one side than the other, much crumpled obliquely in small crumples and transversely in larger folds ; nervation craspedodromous, midrib prominent on both sides, secondaries given off at angles of about 45° and running to the notches of the teeth, all nervation rather confused, and no tertiary nerves to be seen.

Length 32 mm. ; breadth 7.5 mm.

Both fragments are badly preserved, and obscured by crumpling. The crumpling and folding seem to indicate clearly that the leaf was thin and soft.

AFFINITIES : We have found no *Rhus* either living or fossil which resembles this in its complete form, although the tip of the toothed leaf somewhat resembles the figure of *R. macilenta* Saporta (1889, pl. xv, figs. 9, 9a). The base of the leaf is quite unlike that of any living *Rhus*.

The form and size of the leaflet, the character of tothing, texture, nervation, flanged and asymmetric base, are all characters found in pinnae of *Incarvillea olgae* Reg. We have also found the midrib prominent on both sides ; but there is an essential difference : in *Incarvillea* the secondaries do not run either to the cusps or sinuses of the teeth, but passing close to the latter run upwards, and either die out or form filiform loops with the secondaries above ; before reaching the sinus they give off one, or sometimes two, branches to the cusp.

In view of this marked distinction we cannot refer the leaflet to *Incarvillea*. It certainly, however, is not *Rhus*.

- V.17645 Pl. X, figs. 13, 14. Specimen marked RHUS on stone. The impression of the upper part of the leaflet on one of the counterparts, and of the lower part on the other. Fig. 13 is composite, the lower part being printed by reversing the negative of fig. 14.

Dicotylophyllum sp. 3

Plate X, fig. 15.

The impression of the lower surface of the base of a leaf with strong marginal thickening, and a blade attenuated very gradually and gracefully into a long slender stalk; nervation prominent on the lower surface; secondary nerves given off at angles varying from 40° below to 70° above; tertiary nerves given off irregularly at various angles to form a rather coarse network. The two sides of the blade are bent from one another along the midrib at a blunt angle.

- V.17646 Figured Pl. X, fig. 15. Impression of the lower side of the leaf.

Dicotylophyllum sp. 4 (*Radermachera pulchra* ?)

Plate X, fig. 16.

Counterparts which together give the impression of a complete leaf.

Leaf thick, oval, flat, shortly stipitate, margin entire; stalk curved, widening slightly at the base; nerves all prominent on the lower face and scarcely evident on the upper; primary nerve broad and very prominent; secondary nerves much less marked, and emerging from the midrib at rather wide angles varying from 80° below to 50° or 60° above. Their course is obscure, but they appear sometimes to run into the margin without branching, and sometimes to fork so that the branches subtend angles of about 80° , each lower branch anastomosing with the upper branch next below to form an angular loop; tertiary and ultimate nervation too indistinct to be described.

Length 50 mm.; breadth 15 mm.

This leaf, though its perfect form can be discovered, is in such a bad state of preservation that the nervation is extremely difficult to trace; partly because the nerves seem to have been sunk in the thick lamina, but yet more because the whole surface is obscured by mineral change, which has left meandering dark lines obliterating the delicate nerves.

The shape of the leaf and its general character would make it possible that it might belong to *Radermachera*; but the evidence of nervation is too obscure to speak with any certainty. It must remain doubtful. A seed of *R. pulchra* is described from the deposit (p. 129; Pl. VIII, fig. 20).

- V.17009 Figured Pl. X, fig. 16. The impression of the lower part of the lower surface of the leaf. The counterpart is the impression of the tip only of the upper surface.

Dicotylophyllum sp. 5

Plate X, fig. 17.

The specimen shows the impression of a lanceolate leaf of which the extreme base and tip are wanting. It has an entire margin, and appears to have been thick and leathery. The surface is smooth except at the apex where it is wrinkled. The primary nerve is strong and prominent on the lower surface. Secondary nerves, often obscure, are given off at angles of about 50° below, and wider angles above. The shape somewhat resembles that of *Dicotylophyllum* sp. 7, but the secondary nerves make a more acute angle with the midrib than in that species, and are fewer and more obscure.

Length incomplete ; breadth 7 mm.

- V.17647 Figured Pl. X, fig. 17. Impression of lower surface of leaf.

Dicotylophyllum sp. 6

Plate X, fig. 18.

Leaf iliciform, deeply dissected into seven segments, base rounded, sessile? (no petiole is present, but it may be broken), margin strongly rimmed ; of the seven segments, the six lateral (three on each side) are triangular and end in sharp spines, some directed sharply upwards, some sharply downwards as in the holly, the long narrow median segment (imperfect at the tip) is parallel-sided and concave or grooved on the upper face ; nervation pinnate ; secondary nerves, which are given off at angles of about 60° , run to the extremity of each segment.

Length (incomplete at tip) 30 mm. ; breadth 24 mm.

In consequence of the leaf being iliciform and deeply dissected the stone has broken into three pieces, and the form of the leaf can only be discovered by a careful study and combination of the evidence. To assist our own study we made a measured model, and so discovered the form to be that described. Ilciform leaves are found in many genera, but the remarkable parallel-sided apical segment we have been unable to find in any. We compared the fossil with *Ilex*, *Osmanthus*, *Berberis*, *Carduus*, *Oxylobium*, *Acanthus*, and certain Proteaceae, but none suggests a possible relationship.

The only fossil species at all comparable is *Ilex horrida* Saporta (1865) from Armissan ; but it is very much larger, the lobes are much less slender, the apical lobe is triangular, not ligulate, and the lateral lobes are flat, so that again there seems to be no relationship.

V.17648 Figured Pl. X, fig. 18. Impression of leaf, now broken into three fragments, all of which show parts of the impression.

Dicotylophyllum sp. 7

Plate X, fig. 19.

The specimen shows the impression with carbonised remains of two leaves overlapping.

Leaf (or leaflet) oval, lanceolate, entire, leathery, margin recurved; nervation camptodromous; primary nerve very broad, round, and prominent on the under surface, secondary nerves given off at wide angles and but slightly curved, forming a series of sub-marginal loops; tertiary nerves not visible.

Length incomplete; breadth 9 mm.

The base of the uppermost leaf is apparently all but complete, the stalk (if there were one) alone being missing. The apex of the under leaf is distorted and imperfect. The nervation is obscured by the carbonised remains, but unfortunately no cuticle is preserved.

V.17649 Figured Pl. X, fig. 19. Impression of the lower surfaces of two overlapping leaves, with carbonised remains, but no cuticle.

Dicotylophyllum sp. 8

Plate X, fig. 20.

The specimen shows the impression of two narrow lobes of a thin palmate leaf, with entire margin. The lobes make an angle of about 45° with one another, and each has a thin, slightly prominent midrib. The secondary nerves in each lobe are concave upward towards the midrib in the lower part of the leaf, but convex above. These nerves appear to be given off at angles of about 60° , but some of the upper nerves at more acute angles. The nervation is very obscure and is further confused by crumpling. There seems some evidence that the secondary nerves run into a marginal nerve in the upper part of the large lobe. Secondaries from each lobe run towards the sinus, and uniting, pass into it. The ultimate network, which can be seen on the small lobe, is very coarse.

Length of longest lobe (incomplete) 35 mm.

Leaves of somewhat this form were named by Unger *Sterculia labrusca* (1851, p. 175, pl. xlix, figs. 1-11). We compared the fossil with *Sterculia*, but although the shape of leaf is similar, the nervation does not agree.

V.17650 Figured Pl. X, fig. 20. The impression of two lobes of a palmate leaf.

Dicotylphyllum sp. 9

Plate XI, fig. 1.

The fragment of a skeletonised leaf (probably long-lanceolate) ; midrib straight and strong ; secondary nerves emerging at wide angles, and united near the margin by a series of loops so as to form with the midrib a series of rhomboidal areas ; tertiary nerves given off at approximately right angles form a series of polygonal meshes.

V.17651 Figured Pl. XI, fig. 1. Impression of skeleton leaf with counterpart.

V.18150-52 Three specimens which may be of the same species.

Dicotylphyllum sp. 10

Plate XI, fig. 2.

The fragment of a ligulate leaf with long delicate sigmoidal teeth. The secondary nerves are given off at broad angles and run in a curve, slightly concave upwards, to the notches of the teeth.

V.17652 Figured Pl. XI, fig. 2. The impression of the lower surface of the leaf (fragment only).

Dicotylphyllum sp. 11

Plate XI, fig. 3.

Leaf oval (imperfect at the extreme base and apex), margin entire below, but with a few teeth above ; nervation camptodromous, the primary and secondary nerves sunk on the upper surface, and with a fine, but conspicuous, filament in the middle of the channel ; from these filaments very numerous lateral filaments (tertiary and quaternary nerves) are given off at right angles, producing a conspicuous notching of the edges of the channel ; secondary nerves few, conspicuous, sweeping in uniform curves outwards and upward at rather wide angles, the upper angles being rather wider than the lower ; tertiary nerves raised, fine, and rather inconspicuous, given off at right angles from the midrib and secondaries ; quaternary nerves also raised, almost as conspicuous as the tertiaries, given off at right angles from all the others, and forming a close network of polygonal or rhomboidal meshes over the whole surface.

Length (broken) 30 mm. ; breadth 11.5 mm.

The specimen which shows the impression of the upper side of a leaf is labelled "*Viburnum*" in pencil on the stone. As *Viburnum* is one of the genera identified by Gardner and Saporta on the occasion of their visit, it is probable that this is the specimen then determined.

At first sight the nervation is highly reminiscent of *Viburnum*, particularly of *V. tinus*, but a closer scrutiny reveals essential differences. We compared the fossil with all species represented at Kew. It was not uncommon to find the same angle of emergence and the same general lines of curvature of the secondary nerves (*V. tinus*, *V. longistaminum*), but the course of the nerves is more irregular. The primary nerve is sometimes sunk on the upper surface and may, occasionally, have a filament in the middle of this channel; but the tertiary nerves are much less regular, being given off at various angles; they are fewer, and coarser, the quaternary nerves are very much fewer, not given off at right angles, not raised; they and the tertiaries do not give rise to notching, and the ultimate areas are very large, and few, and in no way comparable with those seen in the fossil.

We do not think the specimen belongs to *Viburnum*. We compared the fossil with *Aralia*. Some species show leaves of this form with notched midribs, but again the ultimate nervation was dissimilar.

V.17653 Figured Pl. XI, fig. 3. The impression of the upper side of a leaf.

Dicotylophyllum sp. 12

Plate XI, fig. 4.

Leaf broad, spatulate, roundly emarginate at the apex, narrowed into a fairly long stalk, smooth, thick, coriaceous, with entire margin somewhat reflexed; midrib prominent on the dorsal, and sunk on the ventral face; secondary nervation camptodromous, inconspicuous on both faces through being sunk in the thickness of the leaf, but rather more marked on the upper face; nerves sub-opposite above, filiform, given off at angles of about 80° , bifurcating at about two-thirds the distance from midrib to margin, the branches so formed uniting with the secondaries to form angular loops; tertiary nerves very obscure.

Length including stalk 23 mm.; breadth 10 mm.

Counterparts showing the impressions of both surfaces.

This leaf is labelled "*Caesalpinia?*" but by whom we do not know. It cannot be *Caesalpinia*, as shown by its petiole. When it came into our hands, this petiole was buried in the stone, and was only exposed later by chipping.

V.17654 Figured Pl. XI, fig. 4. Impression of the lower surface of a leaf with petiole, and of part of the upper (counterpart).

V.18153 The lower surface of the apex of a leaf which may belong to the same species, but is very badly preserved.

Dicotylophyllum sp. 13

Plate XI, fig. 5.

Counterpart impressions of part of a sub-ligulate, tapering leaf with long, but slender, sigmoidal teeth ; midrib prominent on the lower face ; secondary nerves, given off at wide angles, run to the notches, and throw off branches which form loops ; short, fine tertiary nerves are given off at right angles to the secondaries, and with the quaternary nerves form coarse quadrangular areoles.

V.17655 The lower surface is figured, Pl. XI, fig. 5.

Dicotylophyllum sp. 14

Plate XI, fig. 6.

Counterparts showing together the impression of the lower part of a narrow elongate-oval, toothed leaf, tapering gradually into the short pedicel ; secondary nerves, which are given off at a broad angle, run into the teeth.

V.17656 Figured Pl. XI, fig. 6.

Dicotylophyllum sp. 15

Plate XI, fig. 7.

Leaf (or leaflet) broad, spatulate, either rounded or emarginate at the apex (slightly imperfect), narrowed into a short stalk, flatly convex on the upper, and concave on the lower side, margin entire ; nervation camptodromous, very conspicuous, prominent on both sides (? skeletonised) ; midrib very broad for the size of the leaf ; secondary nerves few, alternate, arising at angles varying from 45° below to 60° above, bifurcating at about two-thirds the distance between midrib and margin and anastomosing to form a series of loops, which are connected by another series of loops nearer the margin ; tertiary nerves few and very irregular, sometimes uniting the primary and secondaries, sometimes the primary with the loops of the secondaries, or the secondaries with the loops of the secondaries, forming altogether a coarse network.

The leaf is much smaller, and the nervation unlike that of the species figured Pl. XI, fig. 4.

Length (imperfect) 11 mm. ; breadth 7 mm.

V.17657 Figured Pl. XI, fig. 7. The impression of a leaf with counterpart.

Dicotylophyllum sp. 16

Plate XI, fig. 8.

The impression of a very small curled leaf on a twig. It has a conspicuous midrib and craspedodromous nervation.

Length 4 mm. ; breadth 4 mm.

V.17658 Figured Pl. XI, fig. 8. The impression of the lower surface of a leaf.

Dicotylophyllum spp.

V.18225—V.18318 Incomplete fragments belonging to a variety of dicotyledonous leaves.

Sepal or Bract

Plate XI, fig. 9.

A small petaloid recurved bract or sepal (or possibly a petal), oval, with four well-marked delicate nerves diverging from the base and branching dichotomously twice.

Length 2.7 mm. ; breadth 2 mm.

We think it more probable that this specimen represents a sepal or bract than a petal, but cannot identify it.

V.17659 Figured Pl. XI, fig. 9. The impression of a sepal or bract.

Genus **PHYLLITES** Brongniart

1822 *Mém. Mus. Hist. Nat.*, viii. p. 237.

Phyllites sp.

Plate XI, figs. 10, 11 ; text-fig. 15.

The appearance of this fossil when it came into our hands is shown by fig. 10. The two series of cells or hollows were seen to lie at the margins of some kind of lamina, the folds of which were buried in the stone. By careful chipping the two rows of cells were removed without breakage and the underlying lamina exposed. The three separate parts of the specimen so obtained were then measured and drawn as they would lie when flattened. The three drawings thus obtained were then pieced together in their relative positions. The result (see text-fig. 15a) showed that the specimen was the impression of a pinnately lobed leaf, with fructifications along the lower margins of the two bottom lobes. These fructifications are represented by hollow impressions which show no structure. No nervation can be traced with certainty ; but two or three indentations in the stone on the lowest right-hand lobe suggest the possibility of pinnate nerves given off

from the central angle, along which the leaf was sharply bent backwards. Pl. XI, fig. 10, shows the fossil in its original state with the two rows of fructifications flanking the sharply reflexed median fold of the lamina. Fig. 11 shows the specimen after development at the apex, and after the right-hand fructification was removed. To the right near the base can be seen the dark impression of part of the lamina and the upper of the right-hand lobes seen in text-fig. 15*a*. We have not figured the specimen after the removal of the left-hand fructification because it was impossible to show the limits of the lamina satisfactorily.

In the text-figure the shaded parts bounded by black lines represent the parts of the lamina actually preserved with their



FIG. 15.—*Phyllites* sp. *a*, Lamina reconstructed (diagrammatic) $\times 2.5$. *b*, Transverse section through the impression of the lamina. The stippling represents the matrix. V.17660.

margins. The unshaded parts and dotted lines represent the suggested form of parts now missing. The leaf was reflexed sharply along what seems to have been a midrib; the two sides were then folded very sharply forward along the two lateral black lines seen on the lamina in text-fig 15*a*; so that the section was somewhat like that of a W (see text-fig. 15*b*), the two marginal fructifications representing the tips of the two limbs of the W. The bases of the lobes are produced into a long flat stalk strongly margined.

Except the form of this specimen, no structure of any kind is preserved such as might assist in its determination. We think that most probably it is the fructification of a Cryptogam, as we cannot suggest any position for it among Phanerogams.

At first sight it might be thought to have relationship with

Carpolithus sp. 3, figured Pl. IX, figs. 19-22; but the latter is very much larger, and in the specimen under consideration there is no evidence of the locules with their complicated germination valves seen in that species. The possibility of an affinity with *Phyllocladus* has been considered, but the fact that the marginal impressions in the fossil do not agree in character with the ovules in that genus indicates that there is no real relationship.

V.17660 Figured Pl. XI, figs. 10, 11. Impression of lamina with fructification. The specimen is now in three pieces (part of the lamina, and the fructifications attached to the lamina).

ROOTS

Plate XI, figs. 12-14.

Many rock fragments show impressions of detached roots, broken from a stem or rhizome at their point of origin. Figure 13 shows three such roots in juxtaposition, which were evidently given off in association at a node.

Three regions can be distinguished in these roots: (a) The free part of the root from which abundant root fibres may be given off, as seen in fig. 13, or from which they may be absent (fig. 12). (b) A short area nearer the parent stem where the root narrows towards its point of origin. The external casts of this region show horizontal alternations of narrow bands of transverse fibres, and wider bands of parenchymatous tissue, two or three cells deep. (c) A narrow central core or stele which evidently passed into the parent stem.

Other rock specimens show fragments of roots giving off crowded rootlets such as occur in many grasses (fig. 14).

We cannot determine the affinities of any of these isolated organs.

V.17661 Figured Pl. XI, fig. 12. Impression of a root.

V.17662 Figured Pl. XI, fig. 13. Group of three rootlets side by side.

V.17663 Figured Pl. XI, fig. 14. Root with rootlets, and counterpart.

V.18154-56, V.17039 Four sets of counterparts.

V.18157-71 Fifteen specimens of roots.

V.17046 Portion of large root.

STEMS AND RHIZOMES

Plate XI, figs. 15, 16.

Casts and impressions of fragmentary stems or rhizomes occur fairly abundantly; but the evidence is insufficient to determine their relationship with any confidence.

The specimen figured at Pl. XI, fig. 15, is worthy of special mention, because roots are given off below the nodes as indicated by buds above the nodes, and by the way in which the rhizome

thickens. This specimen therefore cannot belong to Gramineae. The same is true of specimen V.18173.

- V.17664 Figured Pl. XI, fig. 15. The external impression of a rhizome.
 A fragment of a monocotyledonous leaf occurs on the same block, and of this there is a counterpart, but not of the rhizome.
- V.17665 Figured Pl. XI, fig. 16. Cast of rhizome.
- V.18172 Cast of large rhizome and counterpart.
- V.18173 Cast of rhizome (? *Equisetum*).
- V.18174-79 Six casts of rhizomes.
- V.6357 Cast of rhizome.

SCARS

Plate XI, figs. 17-20.

The curious scars here figured we have been unable to determine and can suggest no interpretation of them.

- V.17666 Figured Pl. XI, fig. 17. The impression of a scar.
- V.17667 Figured Pl. XI, fig. 18. The impression of a scar or nodal diaphragm.
- V.17668 Figured Pl. XI, fig. 19. An impression with counterpart, which appears to represent the scar of some kind of node or bud.
 The two faces are at right-angles to one another.
- V.17669 Figured Pl. XI, fig. 20. The impression of a scar.
- V.18180-81 Two impressions of scars, with counterparts.

CUTICLES

(a) Plate XI, figs. 21, 22.

A few fragments of cuticle, two of which we figure, have been obtained from broken and indeterminable leaves.

Figs. 21 and 22 show the lower and upper surfaces respectively of one of these. In fig. 21 the narrow oblong guard-cells can be seen with the narrow slit of the stoma between. The guard-cells are considerably thickened at their inner margins, and strongly thickened at the two ends. Each guard-cell has its own surrounding of epidermal cells which is never shared in common with another. These most usually number four, but may be as many as six. The epidermal cells flanking the guard-cells are usually of the same length as these, and straight on their inner margins. The nerves are formed of oblong cells. The epidermal cells of the upper surface are small and polygonal.

- V.17670a Figured Pl. XI, figs. 21, 22. Cuticle from rock-specimen V.17670.

(b) Plate XI, figs. 23, 24.

Cuticle from the minute fragment of an unknown leaf. Fig. 23 shows the upper, and fig. 24 the lower surface. The cuticle of the

upper surface shows nearly equi-axial polygonal thick-walled cells. The lower surface shows stomata scattered fairly uniformly, and with a tendency to be oriented in one direction. The stomata are slightly sunk, the crescentic guard-cells have their inner walls greatly thickened, but otherwise are thin-walled. The central pore is oval. Each stoma is surrounded by four or five epidermal cells. The epidermal cells are very thick-walled.

V.17671 Figured Pl. XI, figs. 23, 24. Cuticle from leaf fragment; slide *a* the upper surface, slide *b* the lower surface.

[“ Flower ”]

1886 Gardner, *Proc. Geol. Assoc.*, IX, pl. iv, fig. 13.

V.17687 This specimen was figured by Gardner as an indeterminate flower. It is more likely to be some kind of fruit, but is too poor for further comment.

CHAROPHYTA

By JAMES GROVES, F.L.S.

THE remains of Charophytes occur in abundance in both the limestones and marls of the Bembridge beds. They consist for the most part of detached oogonia, and, as with those of the other Oligocene and Eocene formations, the coronulae and stalk-cells are invariably missing, owing to the fact that these parts do not secrete lime, as do the spiral-cells of which the main part of the oogonium consists.

In the absence of the coronula it is not possible to ascertain to which of the two main divisions of the group the several types of fruit should be assigned.

Small fragments of stems and branchlets occur sparingly in some of the beds, and a very few stem-nodes have also been found. With the meagre data afforded by the vegetative remains it is not possible to arrive at a reconstruction of the plants. The fruits, moreover, cannot be identified with the vegetative parts, as, in each case where the latter are present, more than one type of fruit has been found.

No one would venture to distinguish living Charophytes by their fruits alone, the difference between those of allied species being usually very slight. Considering that in these Oligocene

fossils the fruits are always found detached, and that a portion of the fruit only is preserved, it is obvious that the discrimination of species is necessarily a somewhat haphazard proceeding. The difficulty is further enhanced by the slight differences brought about by the different conditions of preservation in the various beds.

In some types of fruit the specimens occurring together are of approximately the same size ; in others there is a very wide range of size in the same gathering, which is difficult to account for on the analogy of living species, as, in the latter, lime-shells are present only in full-grown fruits, and these, with the exception of an occasional abnormal specimen, are of a nearly uniform size in each gathering of the same species.

The degree of calcification of the spiral-cells of the oogonia and their consequent prominence differs much in the different types ; in some, notably those of the *medicaginula* type, there is every gradation between slight calcification, when the fruit appears deeply grooved spirally, and complete calcification when the spiral-cells are definitely convex or even swollen in appearance ; in other types all the specimens are calcified in much the same degree, so that they are for the most part uniformly either convex or flat, or, when the calcification is very slight, as in *C. perpusilla*, deeply grooved.

Though reluctant to describe new species on insufficient grounds, the writer feels that in the case of fossil Charophytes, unless a fruit is clearly identical with one already described, it is safer to give a separate specific name than to refer it to a species described from a different horizon which seems nearly similar, though it may quite possibly belong to the latter. It is easier and causes less confusion to reduce a specific name to a synonym, than to disentangle a plant wrongly included in a species by a subsequent author.

In the present state of knowledge of the fossil species it has been thought better to retain all the types here referred to under the parent genus *Chara*, though in all probability some of them belong to separate and possibly extinct genera.

In addition to specimens in the A'Court Smith collection from Gurnard Bay, material from the following localities has been utilised in drawing up these notes :—

Whitecliff Bay and Bembridge Foreland (1917 and 1921, J. G.).

Saltmead Ledge and the vicinity (1919, G. W. C. and J. G.).

Hamstead, just west of Hamstead Ledge (1918, J. G.).

Sconce Point (1919, J. G.).

Thorley, exposure by roadside (1918, J. G.).

My best thanks are due to Mrs. Reid and Miss Chandler for making and arranging the excellent micro-photographs on Pl. XII. I am indebted to Mr. G. W. Colenutt, F.G.S., both for specimens and for kind help in collecting and dealing with the material obtained.

Genus **CHARA** (Vaillant) Linnaeus

1753 Spec. Pl., ed. I, p. 1156.

I. VEGETATIVE REMAINS

The most important of the vegetative remains met with are the two stem-nodes illustrated (Pl. XII, figs. 10, 13, 14), belonging presumably to the same species. These show a diplostephanous bistipulate plant, and therefore presumably a species of *Chara* (*sensu stricto*) sect. *Diplostephanae*. The node (figs. 13, 14) shows the bases of ten to twelve apparently ecorticate branchlets, and some of the lower, as well as the upper, ring of stipulodes. Fig. 10 shows a section just below the node and cutting through the upper ring of stipulodes. The fragments of stem found belong mostly to the type shown in fig. 11, about 700μ in diameter with nine to ten noncontiguous cortical series, the cells somewhat nodulose, of approximately equal diameter (*c.* 120μ). From the number of series the cortex is evidently haplostichous. The portion of a more slender stem (diameter *c.* 300μ) shown in fig. 16 has about twenty cortical series of about equal diameter, and may be presumed to be diplostichous. Fig. 12 shows a fragment of an ecorticate stem with a diameter of *c.* 650μ , and smaller ecorticate fragments with a diameter of *c.* 300μ are probably portions of branchlets.

V.18333 Eleven vegetative fragments mounted on slide. Bembridge Foreland. Presented by J. Groves, Esq., 1926.

II. FRUITS

The following are the different types of fruit, so far as they have been made out, but there are in addition a number of individual specimens of which the identity is uncertain.

1. **Chara medicaginula** (Lamarck) Brongniart

Plate XII, fig. 4 (from Osborne Beds) ; text-fig. 16.

- 1804 *Gyrogonites medicaginula* Lamarck, *Ann. Mus. Hist. Nat. Paris*, V, p. 356.
- 1807 *Gyrogonites medicaginula* Lamarck, *op. cit.*, IX, p. 236, pl. xvii, fig. 7.
- 1809 "Gyrogonite medicaginule" Brard, *op. cit.*, XIV, p. 438, pl. xxvii, figs. 27-29.
- 1810 *Gyrogonites medicaginula* Lamarck: Al. Brongniart, *op. cit.*, XV, p. 381, pl. xxiii, fig. 12.
- 1811 "La Gyrogonite" Desmarest, *Nouv. Bull. Soc. Philom. Paris*, II, pp. 275-77, pl. ii, fig. 5.
- 1812 "La Gyrogonite" Desmarest, *Journ. des Mines*, XXXII, p. 341, pl. viii, fig. 1.
- 1812 "La Gyrogonite" Léman, *Nouv. Bull. Soc. Philom. Paris*, III, pp. 208-10 [108-110].
- 1822 *Chara medicaginula* (Lamarck): Brongniart, *Mém. Mus. Hist. Nat. Paris*, VIII, p. 320, pl. xvii, fig. 5.

- 1822 *Chara medicaginula* (Lamarck): Brongniart, in Cuvier & Al. Brongniart, Descr. Géol. Env. Paris, p. 369, pl. xi, fig. 7.
- 1825 *Bechera medicaginula* (Lamarck): Sternberg, Flora. d. Vorw., IV, p. xxxi.
- 1826 *Chara medicaginula* (Lamarck): Lyell, *Trans. Geol. Soc.*, (2), II, p. 93, pl. xiii, figs. 1-4.
- 1828 *Chara medicaginula* (Lamarck): Brongniart, Prodr. Hist. Vég. Foss., p. 71.
- 1850 *Chara medicaginula* (Lamarck): Unger, Gen. Sp. Pl. Foss., p. 32.
- 1853 *Chara medicaginula* (Lamarck): Forbes, *Q. J. Geol. Soc.*, IX, p. 266.
- 1856 *Chara medicaginula* (Lamarck): Salter, in Forbes, *Mem. Geol. Surv.*, p. 159, pl. vii, figs. 1-2.
- 1866 *Chara medicaginula* (Lamarck): Watelet, Pl. foss. Bass. Paris, p. 52, pl. xv, fig. 3.
- 1869 *Chara medicaginula* (Lamarck): Schimper, *Traité Pal. Vég.*, i, p. 221, atlas, pl. v, figs. 33-42.
- 1920 *Chara medicaginula* (Lamarck): Dollfus & Fritel, *Bull. Soc. Géol. France*, (4), XIX, p. 257, figs. 20-23.

DIAGNOSIS: Oogonium usually very large, diameter 975-1500 μ , nearly spherical, often flattened at the poles, rarely longer than broad. Spiral-cells showing about seven convolutions, usually much swollen at the apex with a depression below the tip. Basal orifice funnel-shaped.

REMARKS: Varying greatly in size, sometimes so much flattened at the poles as to be broader than long; apices of the spiral cells variable, but usually swollen, sometimes so considerably as to form noticeable rosettes, accentuated by the depressions below, which form a sort of neck. From the analogy of living charophytes it may be inferred that the coronula was deciduous. The spiral-cells are often very convex, but there is every gradation in calcification and some present deep grooves. In a few cases the oospores are preserved.



FIG. 16. — *Chara medicaginula* (Lamarck) Brongniart.

C. medicaginula was the first fossil charophyte found, and when discovered the fruit was supposed to be the shell of a mollusc. It is the most distinctive of the Tertiary charophyte types, and it, or allied species, extends over a wide period of geological time. As pointed out by Salter (*loc. cit.*) there seems to be no substantial difference between *C. Wrightii* of the Lower Headon Beds and the present species. Vegetative remains associated with the fruits in some of the beds in the Paris Basin have been ascribed to this species, and are figured as such by Schimper (*loc. cit.*). There is no living charophyte with a fruit resembling that of *C. medicaginula*.

The specimens shown in Pl. XII, fig. 4 (V. 129) are from the Osborne Beds (King's Quay, G. W. Colenutt), in which they are

in a better state of preservation than those of the Bembridge Beds.

52593 Three blocks containing fruits. Binstead, Isle of Wight. *Purchased of Prof. J. Morris, 1863.*

V.18328 Mounted fruits. Saltmead Ledge, G. W. C. & J. G. *Presented by J. Groves, Esq., 1926.*

Also present in gatherings from Whitecliff Bay, and near Saltmead and Hamstead Ledges.

2. *Chara helicteres* Brongniart

Plate XII, fig. 6.

1822 *Chara helicteres* Brongniart, *Mém. Mus. Hist. Nat. Paris*, VIII, p. 321, pl. xvii [vi], fig. 3.

1822 *Chara helicteres* Brongniart, in Cuvier & Al. Brongniart, *Descr. Géol. Env. Paris*, p. 368, pl. xi, fig. 8.

1825 *Bechera helicteres* (Brongniart): Sternberg, *Flora d. Vorw.* IV, p. xxxi.

1850 *Chara helicteres* Brongniart: Unger, *Gen. Sp. Pl. Foss.*, p. 32.

1853 *Chara helicteres* Brongniart: Forbes, *Q. J. Geol. Soc.*, IX, p. 266.

1856 *Chara helicteres* Brongniart: Salter, in Forbes, *Mem. Geol. Surv.*, p. 159, pl. vii, figs. 3-5.

1869 *Chara helicteres* Brongniart: Schimper, *Traité Pal. Vég.*, p. 222, Atlas, pl. v, figs. 20-32.

1920 *Chara helicteres* Brongniart: Dollfus & Fritel, *Bull. Soc. Géol. France*, (4), XIX, p. 245, figs. 1-5.

1921 *Chara helicteres* Brongniart: Reid & Groves, *Q. J. Geol. Soc.*, LXXVII, p. 186, pl. v, fig. 11.

DIAGNOSIS: Oogonium very large, 1000-1450 μ long, 900-1200 μ broad, obovoid-ellipsoid, usually truncate above and narrowing slightly towards the base. Spiral-cells showing 9-11 convolutions, somewhat swollen at the apex, with a depression below. Basal orifice broadly funnel-shaped.

REMARKS: One of the largest and most distinctive of the Tertiary types of fruit, usually broadest about the middle, but the lower half tapering more than the upper, which is usually more or less truncate; a clear light brown, smooth and often shiny; the spiral cells convex, the tips tumid with a depression below, but rather less marked than in *C. medicaginula*, and the basal orifice rather more open. Presumably the coronula was deciduous. Brongniart describes the number of convolutions visible as eight, but, if the Bembridge fossils are correctly referred to his species, this is variable. The number of convolutions can hardly be expected to be a fixed character in any species, indeed the wonder is, considering that the cells are originally straight, and gradually assume the spiral, that there is as much approach to uniformity in each species as we find to be the case.

Dollfus & Fritel (*loc. cit.*) refer *C. sparnacensis*, *C. onerata*, *C. Dutemplei* Watelet and *C. Brongniarti* Hébert (non Braun) to this species. *C. helicteres*, as here interpreted, occurs also in the Hamstead and Lower Headon Beds.

- V.18330 Figured Pl. XII, fig. 6. Fruits mounted on slide. Bembridge Foreland. Presented by J. Groves, Esq., 1926.
Also present in gatherings from Whitecliff Bay and Saltmead Ledge.

3. *Chara tuberculata* Lyell

Plate XII, fig. 1; text-fig. 17.

- 1826 *Chara tuberculata* Lyell, *Trans. Geol. Soc.*, (2), II, p. 94, pl. xiii, figs. 7-8.
1828 *Chara tuberculosa* [sic] Brongniart, *Prodr. Hist. Vég. Foss.*, p. 72.
1850 *Chara tuberculata* Lyell: Unger, *Gen. Sp. Pl. Foss.*, p. 33.
1853 *Chara tuberculata* Lyell: Forbes, *Q. J. Geol. Soc.*, IX, p. 267.
1856 *Chara tuberculata* Lyell: Salter, in Forbes, *Mem. Geol. Surv.*, pp. 159-60, pl. vii, figs. 11-14.
1869 *Chara tuberculata* Lyell: Schimper, *Traité Pal. Vég.*, I, p. 222.
1897 *Chara tuberculata* Lyell: Dollfus, *Bull. Soc. Géol. France*, (3), XXV, p. 605, 607.
1920 *Chara Archiaci* Wat. var. *tuberculata* (Lyell): Dollfus & Fritel, *Bull. Soc. Géol. France*, (4), XIX, p. 252.

DIAGNOSIS: Oogonium large, about 900-1150 μ long, 800-1000 μ broad, broadly ellipsoid, scarcely tapering below, with a short projecting pentagonal base, diameter about 120 μ . Spiral-cells showing about 10-11 convolutions, usually not swelling at the apex, each with a row of somewhat irregular, rough, more or less truncate tubercles, at nearly equal intervals, and often connected by a ridge.

REMARKS: The outstanding characteristics of this type are the broadly ellipsoid shape, the presence of rows of tubercles on the spiral-cells and the projecting pentagonal base (see text-fig. 17). The nature of the curious irregular tubercles from which the name was taken, and which are also present in the following species, is problematic. Canon Bullock-Webster, who has given special attention to the study of the fruits of living Charophytes, has found



FIG. 17.—*Chara tuberculata* Lyell. Base.

fruits of *C. delicatula* Ag. covered with a thick external incrustation, broken up into fairly even projecting parts, and therefore somewhat resembling these fossils. In the living species, however, the projections are contiguous, whereas in *C. tuberculata* and *C. vasiformis* they always stand well apart at fairly regular intervals, though, in what is apparently an advanced stage, they are connected more or less by a ridge. Moreover, Mr. D. J. Scourfield's investigations in the case of *C. vasiformis* (Reid & Groves, 1921, p. 185) elicited the fact that the projections consist partly of organic matter, and cannot therefore be the result of mere incrustation.

The sutures of the spiral-cells usually appear as distinctly

raised lines. Many of the oogonia have a partial dark lining representing portions of the oospore membrane.

C. tuberculata is the type most characteristic of the Bembridge beds, and is present, usually in abundance, in almost all the gatherings mentioned. It occurs also in the Hamstead beds. The species was originally described by Lyell from specimens obtained at Whitecliff Bay.

V.18320 Figured Pl. XII, fig. 1. Fruits mounted on slide. A'Court Smith Collection.

V.18336 Tube containing numerous fruits. A'Court Smith Collection.

V.18337 Two blocks with fruits. Whitecliff Bay. Brit. Mus., Old Collection.

4. *Chara vasiformis* Reid & Groves.

Plate XII, fig. 9.

1921 *Chara vasiformis* Reid & Groves, *Q. J. Geol. Soc.*, LXXVII, p. 185, pl. iv, figs. 12-15.

DIAGNOSIS: Oogonium medium-sized, about $625-825\mu$ long, $475-575\mu$ broad, obovoid ellipsoid, tapering somewhat below, with a projecting pentagonal base. Spiral-cells showing about 10-11 convolutions, not swelling at the apex, each with a row of somewhat irregular, rough, more or less truncate tubercles, at nearly equal intervals, and often connected by a ridge.

REMARKS: Evidently very nearly related to *C. tuberculata* and not always readily separable from it, but smaller, relatively narrower, and usually tapering downwards. The pentagonal base is less pronounced in the fruits from the Bembridge Beds than those from the Lower Headon Beds, from which latter the species was described.

V.18332 Figured Pl. XII, fig. 9. Saltmead Ledge, G. W. Colenutt & J. Groves. *Presented by J. Groves, Esq.*, 1926.

5. *Chara vespiformis* n. sp.

Plate XII, figs. 5, 7; text-fig. 18.

DIAGNOSIS: Oogonium medium-sized, about $700-800\mu$ long, $425-500\mu$ broad, elongate-obovoid, slightly narrowed above to a truncate apex, narrowed gradually below with a curved outline to the small rather acute base. Basal aperture very small. Spiral-cells showing about 12-13 convolutions, apparently somewhat swollen at the apex.

REMARKS: A distinct-looking type, rather smooth and shiny, in outline resembling the abdomen of a wasp, the lime-shell imperfectly developed above so that in nearly all the specimens the upper part is lacking. The spiral-cells are usually flat, and as far as can be made out their tips are somewhat swollen.



FIG. 18. —
Chara vespiformis n. sp.

- V.18325 Fruits mounted on slide. A'Court Smith Collection.
 V.18326 Fruits mounted on slide. Bembridge Foreland. *Presented by J. Groves, Esq.*, 1926.
 V.18327 Seven fruits mounted on slide, syntypes. Bembridge Foreland. *Presented by J. Groves, Esq.*, 1926.
 Also found at Saltmead Ledge, G. W. C. & J. G.

6. *Chara subglobosa* n. sp.

Plate XII, fig. 3.

DIAGNOSIS: Oogonium small, about $425-475\mu$ long, $350-400\mu$ broad, globose-ellipsoid to nearly spherical, narrowing about equally towards the apex and the base. Basal orifice small, diameter about 55μ . Spiral-cells usually convex, nodulose, sometimes with each extremity somewhat swollen.

REMARKS: Quite distinct from any of the other types from these beds, very broadly ellipsoid, pale yellowish brown with a dull nodulose surface, the spiral-cells rarely at all concave.

- V.18331 Fourteen fruits mounted on slide, syntypes. Marl, Whitecliff Bay. *Presented by J. Groves, Esq.*, 1926.
 Also found near Hamstead Ledge.

7. *Chara vectensis* n. sp.

Plate XII, figs. 2, 8; text-fig. 19.

DIAGNOSIS: Oogonium extremely variable in size, $800-1000\mu$ long, $500-800\mu$ broad, ellipsoid, but varying considerably in relative length and breadth. Basal orifice about 50μ in diameter. Spiral-cells showing 9-10 convolutions, usually swollen at the apex, often forming prominent rosettes.

REMARKS: This name is given provisionally to cover a large number of ellipsoid fruits which do not belong to any of the other types, and which, in spite of the great disparity of shape and size, I have not been able to separate satisfactorily. It is quite likely, however, that they may represent more than one species. In some specimens the swollen apices of the spiral-cells are very marked. The greater number of specimens have the spiral-cells convex or flat, comparatively few concave. By far the majority of the fruits in the A'Court Smith collection come under this type.



FIG. 19. —
Chara vectensis n. sp.
 Apex.

- V.18321-2 Thirty fruits mounted on slides, syntypes. A'Court Smith Collection.
 V.18335 Tube containing numerous fruits. A'Court Smith Collection.
 Also found at Whitecliff Bay and Saltmead Ledge.

8. *Chara* [*Tolypella* ?] *perpusilla* n. sp.

Text-fig. 20.

DIAGNOSIS: Oogonium minute, about $275\text{--}300\mu$ long, $200\text{--}250\mu$ broad, ellipsoid, narrowing nearly equally towards each extremity. Basal orifice about 35μ in diameter. Spiral cells concave, about $30\text{--}40\mu$ wide, apparently not swelling at the apex, showing about 12 convolutions.

REMARKS: The smallest charophyte which has, I believe, yet been found in Tertiary deposits. Much resembling the two tiny types of fruit from the Lower Headon beds referred by Reid and Groves (1921, p. 188) to the genus *Tolypella*, but still more minute than the smaller of them, tapering rather more decidedly to each extremity, and the spiral cells showing more convolutions. Found in very small quantity.



FIG. 20. —
Chara per-
pusilla n. sp.

V.18334 Four specimens mounted on slide, syntypes. Marl, Whitecliff Bay. Presented by J Groves, Esq., 1926.

NOTE.—The citation in brackets of the original author of a species when the species has been transferred to another genus, though not a usage followed by all describers of Recent plants, has been adopted here to conform with the other publications of the Geological Department.

LIST OF WORKS QUOTED

- BANDULSKA, H. 1923 A Preliminary Paper on the Cuticular Structure of certain Dicotyledonous and Coniferous leaves from the Middle Eocene Flora of Bournemouth. *Journ. Linn. Soc. Bot.*, XLVI, pp. 241-69, pls. xx, xxi.
- BERRY, E. W. 1911 An *Engelhardtia* from the American Eocene. *Amer. Journ. Sci.*, (4) XXXI, pp. 491-96.
- 1916 The Lower Eocene Floras of South-eastern North America. *U.S. Geol. Surv.*, Prof. Paper 91.
- BOUSSAC, J. 1907 La Limite de l'Eocène et de l'Oligocène. *Bull. Soc. Géol. France*, (4) VII, pp. 400-411.
- BRARD, P. 1809 Sur les coquilles fossiles du genre *Lymnée* qui se trouve aux environs de Paris. *Ann. Mus. Hist. Nat. Paris*, XIV, pp. 426-440, pl. xxvii.
- BRISTOW, H. W., REID, C. 1889 The Geology of the Isle of Wight, 2nd ed. *Mem. Geol. Surv. England and Wales*.
- BRONGNIART, AD. 1822 Sur la classification et la distribution des végétaux fossiles. *Mém. Mus. Hist. Nat. Paris*, XIII, pp. 203-348, pls. xii-xvii [i-vi].
- 1828 Prodrôme d'une histoire des Végétaux fossiles. viii + 223 pp. Paris.
- 1828a Notice sur les Plantes d'Armissan, près Narbonne. *Ann. Sci. Nat.*, XV, pp. 43-51, pl. iii.
- BRONGNIART, AL. 1810 Description des fossiles qu'on trouve dans les terrains d'eau douce. *Ann. Mus. Hist. Nat. Paris*, XV, pp. 365-405, pls. xxii, xxiii.
- CAMPBELL, D. H. 1899 Studies on the Flower and Embryo of *Sparganium*. *Proc. California Acad. Sci.*, (3) I, pp. 293-328, pls. xlv-xlviii.
- CHANDLER, M. E. J. 1922 *Sequoia Couttsiae*, Heer, at Hordle, Hants: A Study of the Characters which serve to distinguish *Sequoia* from *Athrotaxis*. *Ann. Bot.*, XXXVI, pp. 385-90.

- CHANDLER, M. E. J. 1923 Geological History of the Genus *Stratiotes*. *Quart. Journ. Geol. Soc.*, LXXIX, pp. 117-138, pls. v, vi.
- 1925 The Upper Eocene Flora of Hordle, Hants. Pt. I, pp. 1-32, pls. i-iv. *Monogr. Palaeont. Soc. London*.
- CONWENTZ, H. 1886 Die Flora des Bernsteins, II. Danzig.
- CUVIER, G. & 1822 Descriptions Géologique des Environs de Paris. 3rd ed.
- BRONGNIART, AL.
- DESMAREST, A. G. 1811 Mémoire sur la Gyrogonite. *Nouv. Bull. Soc. Philom. Paris*, II, pp. 275-77, pl. ii. [Extract from Desmarest 1812.]
- 1812 Mémoire sur la Gyrogonite. *Journ. des Mines*, XXXII, pp. 341-360, pl. viii.
- DIXON, F. 1850 Geology of Sussex, ed. 1. London.
- & JONES, T. R. 1878 Geology of Sussex, ed. 2. Brighton.
- DOLLFUS, G. 1897 Recherches sur la Limite Sud-ouest du Calcaire Grossier dans le Bassin de Paris. *Bull. Soc. Géol. France* (3) XXV, pp. 597-637.
- & 1920 Catalogue Raisonné des Characées Fossiles du Bassin de Paris. *Bull. Soc. Géol. France* (4), XIX, pp. 243-61.
- FRITEL, P. H.
- DUNAL, F. 1848 Sur une nouvelle espèce fossile de Prêle. *Mém. Acad. Sci. Montpellier*, I, pp. 169-71, 1 pl.
- ENGELHARDT, H. 1870 Flora der Braunkohlenformation im Königreich Sachsen. *Preisschriften Fürstlich Jablonowskischen Gesellsch.*, No. XVI, pp. 1-69, Atlas xv pls.
- 1922 Die Alttertiäre Flora von Messel bei Darmstadt. *Abh. Geol. Landesanst. Darmstadt*, VII, 4, pp. 21-128, pls. i-xl.
- ENGLER, A. 1889 Die natürlichen Pflanzenfamilien, II, pt. 3.
- ETTINGSHAUSEN, C. VON 1851 Fossile Flora von Wien. *Abh. Geol. Reichsanst. Wien*, II, No. 1, pp. 1-36, pls. i-v.
- 1853 Die Tertiäre Flora von Häring in Tirol. *Abh. Geol. Reichsanst. Wien*, II, No. 2, pp. 1-118, pls. i-xxxi.
- 1854 Die Eocene Flora des Monte Promina. *Denkschr. Ak. Wiss. Wien*, VIII, pp. 17-44, pls. i-xiv.
- 1858 Beiträge zur kenntnis der fossilen Flora von Sotzka in Untersteiermark. *Sitzber. Ak. Wiss. Wien*, XXVIII, pp. 471-567, pls. i-vi.
- 1867 Die fossile Flora des Tertiär-Beckens von Bilin, Pt. i. *Denkschr. Ak. Wiss. Wien*, XXVI, pp. 79-174, pls. i-xxx.

- ETTINGSHAUSEN, C. VON 1868 Ditto, Pt. ii, *op cit.*, XXVIII, pp. 191-242, pls. xxxi-xxxix.
- 1869 Ditto, Pt. iii, *op. cit.*, XXIX, pp. 1-110, pls. xl-xlv.
- 1877 Die fossile Flora von Sagor in Krain. Pt. ii, *op. cit.*, XXXVII, pp. 161-216, pls. xi-xxvii.
- FORBES, E. 1853 On the Fluvio-marine Tertiaries of the Isle of Wight. *Quart. Journ. Geol. Soc.*, IX, pp. 259-70.
- 1856 On the Tertiary Fluvio-Marine Formation of the Isle of Wight. *Mem. Geol. Surv. England and Wales*, xviii + 162 pp., x pls.
- FRANCHET, A. 1891 *Dipelta yunnanensis*. *Rev. Horticole*, pp. 246-47.
- GARDNER, J. S. 1879 On the British Eocenes and their Deposition. *Proc. Geol. Ass.*, VI, pp. 83-106, pl. i.
- 1883-86 A Monograph of the British Eocene Flora. II, Gymnosperms. *Monogr. Palaeont. Soc. London*.
- 1886a The Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom. *Rep. Brit. Ass.* (1885), pp. 396-404, pls. i-iii.
- 1886b Fossil Grasses. *Proc. Geol. Ass.*, IX, pp. 433-54, pls. iv, v.
- 1888 On the Higher Eocene Beds of the Isle of Wight. *Rep. Brit. Ass.* (1887), pp. 414-23, pls. iii, iv.
- & 1879-82 A Monograph of the British Eocene Flora, I. Filices. *Monogr. Palaeont. Soc. London*.
- ETTINGSHAUSEN, C. VON
- GAUDIN, C. T. & 1860 Contributions à la Flore Fossile Italienne. 2. Val d'Arno. *N. Denkschr. Schweiz. naturf. Ges. Zurich*, XVII, No. 4, pp. 1-59, pls. i-x.
- STROZZI, C.
- GOEPPERT, H. R. 1850 Monographie der fossilen Coniferen. Leiden.
- GRAY, A. 1859 Diagnostic Characters of New Species of Phaenogamous Plants, collected in Japan . . . with Observations upon the Relations of the Japanese Flora to that of North America and of other parts of the Northern Temperate Zone. *Mem. Amer. Acad. Arts Sci. Boston*, n.s., VI, pp. 377-452.
- HARTZ, N. 1909 Bidrag til Danmarks Tertiaere og Diluviale Flora. *Danmarks Geol. Undersøg.* (2) No. 20, 292 pp., atlas 13 pls.
- HEER, O. 1855-59 Flora Tertiaria Helvetiae, 3 vols. Winterthur.

- HEER, O. 1861 Recherches sur le Climat et la Végétation du Pays Tertiaire. Translation by C. T. Gaudin, 220 + xxii pp., 2 pls. Geneva & Paris.
- 1862 On Certain Fossil Plants from the Hempstead Beds of the Isle of Wight. *Quart. Journ. Geol. Soc.*, XVIII, pp. 369-77, pl. xviii.
- 1862a On the Fossil Flora of Bovey Tracey. *Phil. Trans. R. Soc.*, CLII, pp. 1039-86, pls. lv-lxxi.
- 1869 Miocene Baltische Flora. *Beitr. Naturkunde Preuss.*, II, pp. 1-104, pls. i-xxx.
- HOLLICK, A. 1923 The Taxonomic and Morphologic Status of *Ophioglossum Alleni* Lesquereux. *Bull. Torrey Bot. Club*, L, pp. 207-13, pls. x-xii.
- HOOKE, J. D. 1855 On some Minute Seed-vessels (*Carpolithes ovulum* Brongniart), from the Eocene Beds of Lewisham. *Quart. Journ. Geol. Soc.*, XI, pp. 562-65, pl. xvi.
- JUDD, J. W. 1880 On the Oligocene Strata of the Hampshire Basin. *Quart. Journ. Geol. Soc.*, XXXVI, pp. 137-77, pl. vii.
- KNOWLTON, F. H. 1919 A Catalogue of the Mesozoic and Cenozoic Plants of North America. *U.S. Geol. Surv.*, Bull. 696.
- KORZHINSKY, S. 1887 Zur Kenntniss der *Aldrovandia vesiculosa* L. [In Russian]. *Trud. Obshch. Est. Kazan*, XVII, No. 1, pp. 1-98, pls. i-iii.
- KRÄUSEL, R. 1920 Nachträge zur Tertiärflora Schlesiens. I. *Jahrb. Geol. Landesanst. Berlin*, XXXIX, I, pp. 329-417, pls. xvi-xxvii.
- 1921 Ditto, III., *op. cit.*, XL, I, pp. 363-433, pls. v-xv.
- LAMARCK, J. B. 1804 Sur les Fossiles des Environs de Paris. *Ann. Mus. Hist. Nat. Paris*, V, pp. 349-57.
- 1807 Ditto, *op. cit.*, IX, pp. 236-40, pls. xvii-xx.
- LAPPARENT, A. DE 1900 Traité de Géologie. 3 vols. 4th ed. Paris.
- LAURENT, L. 1899 Flore des calcaires de Célas. *Ann. Mus. Hist. Nat. Marseille* (2) I, pt. 2, 148 pp., 14 pls.
- & 1923 Flore Foliaire Pliocène des Argiles de Reuver. *Med. Rijks Geol. Dienst.* (B) No. 1, 80 pp., xiv pls.
- MARTY, P.

- LÉMAN, S. 1812 Note sur la Gyrogomite. *Nouv. Bull. Soc. Philom. Paris*, III, pp. 208-10 [108-10].
- LUDWIG, R. 1860 Fossile Pflanzen aus der ältesten Abtheilung der Rheinisch-Wetterauer Tertiär-Formation. *Palaeontogr.* VIII, pp. 39-154.
- LYELL, C. 1826 On a Recent Formation of Freshwater Limestone in Forfarshire . . . and an Appendix on the Gyrogonite or Seed-vessel of the *Chara*. *Trans. Geol. Soc.*, (2) ii, pp. 73-96, pls. x-xiii.
- MANTELL, G. A. 1851 Petrifications and their teachings; or, a Handbook to the Gallery of Organic Remains of the British Museum. London.
- 1854 Geological Excursions round the Isle of Wight. London.
- MARION, A. F. 1888 *Doliosirobus Sternbergii*. *Ann. Sci. Geol.*, XX, No. 3, pp. 1-20, pls. i, ii.
- MENZEL, P. 1913 Beitrag zur Flora der Niederrheinischen Braunkohlenformation. *Jahrb. Geol. Landesanst. Berlin*, XXXIV, pp. 1-98, pls. i-vii.
- 1922 Ueber hessische fossile Pflanzenreste. *Jahrb. Geol. Landesanst. Berlin*, XLI., pt. i, no. 2, pp. 340-91, pls. xiv-xviii.
- NEWBERRY, J. S. 1898 The Later Extinct Floras of North America. *U.S. Geol. Surv.*, Monogr. XXXV.
- REID, C. 1898 On *Limnocarpaceae*, a new genus of Fossil Plants from the Tertiary Deposits of Hampshire. *Journ. Linn. Soc. Bot.*, XXXIII, pp. 464-66.
- & GROVES, J. 1921 The Charophyta of the Lower Headon Beds of Hordle Cliffs (South Hampshire). *Quart. Journ. Geol. Soc.*, LXXVII, pp. 175-92, pls. iv-vi.
- & REID, E. M. 1907 The Fossil Flora of Tegelen-sur-Meuse, near Venloo in the Province of Limburg. *Verh. K. Ak. Wet. Amsterdam*, XIII, No. 6, pp. 1-26, pls. i-iii.
- ————— 1910 A Further Investigation of the Pliocene Flora of Tegelen. *Versl. Wis. Nat. Afd. K. Ak. Wet. Amsterdam*, XIX. [Proc. Sect. Sci., XIII, pp. 192-201, 1 pl.]
- ————— 1910a The Lignite of Bovey Tracey. *Phil. Trans. Roy. Soc.*, (B) CCI, pp. 161-78, pls. xv, xvi.
- ————— 1915 The Pliocene Floras of the Dutch-Prussian Border. *Med. Rijksops. Delfstoffen*, No. 6.

- REID, E. M. 1920 On Two Preglacial Floras from Castle Eden (County Durham). *Quart. Journ. Geol. Soc.*, LXXVI, pp. 104-44, pls. vii-x.
-
- 1920a A Comparative Review of Pliocene Floras, Based on the Study of Fossil Seeds. *Quart. Journ. Geol. Soc.*, LXXVI, pp. 145-61.
-
- 1920b Recherches sur Quelques Graines Pliocènes du Pont-de-Gail (Cantal). *Bull. Soc. Géol. France*, (4) XX, pp. 48-87, pls. iii, iv.
-
- 1923 Nouvelles Recherches sur les Graines du Pliocène inférieur du Pont-de-Gail (Cantal). *Bull. Soc. Géol. France*, (4), XXIII, pp. 308-55, pls. x, xi.
- RENAULT, M. B. 1881-85 Cours de Botanique Fossile, 4 vols. Paris.
- SAPORTA, G. DE 1862-73 Etudes sur la végétation du Sud-Est de la France à l'époque tertiaire. *Ann. Sci. Nat. Bot.*, (4) XVI, 1862, pp. 309-45; XVII, 1862, pp. 191-311, pls. i-xiv; XIX, 1863, pp. 5-124, pls. i-xi; (5) III, 1865, pp. 5-152, pls. i-viii; IV, 1865, pp. 5-264, pls. i-xiii; VIII, 1867, pp. 5-136, pls. i-xv; IX, 1868, pp. 5-62, pls. i-vii; XV, 1872, pp. 277-351, pls. xv, xvi; XVII, 1873, pp. 5-44, pls. i-v; XVIII, 1873, pp. 23-146, pls. vi-xviii.
-
- 1866 Remarques sur les Genres de Végétaux actuels dont l'existence à été constatée à l'état fossile. *Bull. Soc. Bot. France*, XIII, pp. 189-213.
-
- 1879 Le Monde des Plantes avant l'apparition de l'homme. Paris.
-
- 1886 Nouveaux documents relatifs à des fossiles végétaux et à des traces d'Invertébrés associés dans les anciens terrains. *Bull. Soc. Géol. France*, (3) XIV, pp. 407-30, pls. xviii-xxii.
-
- 1888 Origine paléontologique des arbres cultivés. Paris.
-
- 1888a Dernières Adjonctions à la flore fossile d'Aix en Provence. *Ann. Sci. Nat. Bot.*, (7) VII, pp. 1-104, pls. i-x.
-
- 1889 Dernières Adjonctions etc. 2^{me}. partie. *Ann. Sci. Nat. Bot.*, (7) X, pp. 1-192, pls. i-xx.
-
- 1890 Revue des travaux de paléontologie végétale. *Rev. gén. Bot.*, II, pp. 225-39, pls. xi-xiv.

- SAPORTA, G. DE 1891-92 Recherches sur la végétation du niveau aquitainien de Manosque. *Mém. Soc. Géol. France*, Paléont., No. 9, Pt. I (1891), pp. 1-34, pls. i-vii, Pt. II. (1892), pp. 35-83, pls. viii-xx.
- & MARION, A. F. 1881-85 L'Evolution du Règne végétale. 3 vols. Paris.
- SARGENT, C. S. 1911-17 *Plantae Wilsonianae*. 3 vols. *Publications of the Arnold Arboretum*, No. 4.
- SCHIMPER, W. P. 1869-74 Traité de paléontologie végétale. 3 vols. and atlas. Paris.
- SEWARD, A. C. 1919 Fossil Plants, Vol. IV. Cambridge.
1924 A collection of Fossil Plants from South-Eastern Nigeria. *Bull. Geol. Surv. Nigeria*, No. 6, pp. 66-81, pl. i.
- STAMP, L. D. 1921 On Cycles of Sedimentation in the Eocene Strata of the Anglo-Franco-Belgian Basin. *Geol. Mag.*, LVIII, pp. 108-14, 146-57, 194-200.
- STERNBERG, G. VON 1820-38 Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt. Leipzig & Prague.
- STIZENBERGER, E. 1851 Uebersicht der Versteinerungen des Grossherzogthums Baden. Freiburg.
- STRASBURGER, E. 1873 Ueber *Azolla*, 86 pp., 7 pls. Jena.
- UNGER, F. 1841-47 *Chloris protogaea*. Beiträge zur Flora der Vorwelt. Leipzig.
1850 *Genera et Species Plantarum Fossilium*. Vienna.
————— 1851 Die Fossile Flora von Sotzka. *Denkschr. Ak. Wiss. Wien*, II, pp. 131-97, pl. xxii-lxviii.
————— 1852 *Iconographia plantarum fossilium*. *Denkschr. Ak. Wiss. Wien*, IV, pp. 73-118, pls. xxiv-xlv.
————— 1866 *Sylloge plantarum fossilium*, pars III, *Denkschr. Ak. Wiss. Wien*, XXV, pp. 1-76, pls. i-xxiv.
————— 1869 Die Fossile Flora von Radoboj. *Denkschr. Ak. Wiss. Wien*, XXIX, pp. 125-70, pls. i-v.
- VISIANI, R. DE 1858 Pianta fossili della Dalmazia. *Mem. Ist. Ven.*, VII, pp. 423-48, pls. i-vi.
- WARD, F. K. 1921 In Farthest Burma. London.
- WATELET, A. 1866 Description des Plantes Fossiles du Bassin de Paris. Texte, 264 pp.; atlas, lx pls.
- WHITE, H. J. O. 1915 Geology of the Country near Lymington and Portsmouth. *Geol. Surv. England & Wales*, Expl. Sheets 330, 331.
- WILSON, E. H. 1913 A Naturalist in Western China. 2 vols. London.

WOODWARD, H.

1879 On the occurrence of *Branchipus* (or *Chirocephalus*) in a fossil state associated with *Eosphaeroma* and with numerous Insect Remains in the Eocene Freshwater (Bembridge) Limestone of Gurnet Bay, Isle of Wight. *Quart. Journ. Geol. Soc.*, XXXV, pp. 342-50, pl. xiv.

EXPLANATION OF PLATES

PLATE I

Acrostichum Lanzaeanum (Visiani), p. 33.

- FIG. 1. Impression of pinnule, margins incomplete. $\times 2$. V.17490.
FIG. 2. Impression of a small pinnule, nearly perfect. $\times 1$. V.17491.
FIG. 3. Impression of a fragment of a larger pinnule showing the broad midrib and the curvilinear secondary nerves. $\times \frac{2}{3}$. V.17492.
FIG. 4. Impression of two pinnules arising from the rachis. Lower Headon, Hordle. $\times \frac{3}{8}$. Keeping Collection, Sedgwick Museum.
FIG. 5. Actual carbonised pinnule. Lower Headon, Hordle. $\times \frac{2}{3}$. Keeping Collection, Sedgwick Museum.

Filicales Incertae sedis, p. 37.

- FIG. 6. Sp. 1. An incomplete pinnule. $\times 4$. V.17493.
FIG. 7. Sp. 2. Small pinnule. $\times 2$. V.17494.
FIG. 8. Sp. 3. Fragmentary pinnule (impression). $\times 2$. V.17495.
FIG. 9. Sp. 4. Fragment of a pinnule (impression). $\times 6$. V.17496.
FIG. 10. Sp. 5. Impressions of pinnae, one showing the apex. $\times 2$. V.17497.
FIG. 11. Sp. 5. Impressions of pinnae, one very nearly perfect. $\times 2$. V.17498.
FIG. 12. Sp. 6. Large fragment of a frond (impression), showing the habit. $\times 2$. V.17499.
FIG. 13. Sp. 6. Well-preserved impression, nervation clearly shown. The three fragments clearly belong to one frond. $\times 2$. V.17500.

Azolla prisca n. sp., p. 40.

- FIG. 14. Much branched tuft of foliage showing habit. $\times 3$. V.17002.
FIG. 15. A solitary macrosporocarp showing the relationship to the foliage, and the sharply pointed apex. $\times 25$. V.17501.
FIG. 16. A group of three associated macrosporocarps (impressions) with two actual macrosporangia. $\times 25$. V.17502.
FIG. 17. A tuft of foliage with a microsporocarp near the base full of massulae. $\times 4$. V.17001.
FIG. 18. A microsporocarp (impression) full of microsporangia (the globular bodies at the centre). At the edges the microsporangia are dividing up into their component massulae. Small white dots represent the glistening tips of glochidia. $\times 20$. V.17502.

Figs. 19-23 represent fruiting organs detached and mounted in glycerine.

- FIG. 19. A macrosporangium with three floats visible and closely pressed together—the normal condition. The remains of the sporangium are preserved over the apex; the macrospore at the base is covered by a felted mass of hairs. $\times 30$. V.17503.
- FIG. 20. A macrosporangium after treatment with HNO_3 partially to separate the floats, three of which are clearly shown. To the left a massula can be seen adhering to the top of the spore. $\times 30$. V.17504.
- FIG. 21. A macrosporangium with floats removed; the distorted remains of the fibrous matter in which they were embedded are seen at the apex. At the base the tubercled macrospore is visible, the felted hairs which conceal the tubercles having been largely removed. $\times 30$. V.17504.
- FIG. 22. Two massulae after treatment with HNO_3 and KClO_3 . They show the cellular structure and non-septate glochidia. $\times 158$. V.17001a.
- FIG. 23. A group of microspores, liberated from a massula, shreds of which remain adhering to the spores. On some spores tri-radiate markings can be seen. $\times 316$. V.17505a.

PLATE II

[Figs. 10–16 are from photographs by Dr. Rudolf Florin.]

Equisetum lombardianum Sap. ? p. 44.

- FIG. 1. Internal cortical cast of a large stem with at least 75 lacunae. $\times 1$. V.17506.
- FIG. 2. External impression of a small stem. $\times 2$. V.17507.
- FIG. 3. Internal cortical cast of the same stem (opposite side) which has only about twenty-one lacunae. $\times 2$. V.17507.
- FIG. 4. A node with impressions of three branches at the left-hand side. $\times 2$. V.17508.
- FIG. 5. Impression of an isolated nodal diaphragm. $\times \frac{9}{11}$. V.17509.

Araucarites gurnardi Florin n. sp., p. 48.

- FIG. 6. Impression of a twig. $\times 2$. V.17510.
- FIG. 7. Carbonaceous twig embedded in soft marl. $\times 2$. V.17511.
This specimen yielded the cuticles in figs. 10, 11, 13–16.
- FIG. 8. Impression of twig, showing a denser type of foliage with somewhat shorter leaves. $\times 2$. V.17512.
- FIG. 9. Impression of twig showing branching and habit. $\times 1$. V.17513.
- FIG. 10. Cuticle. Three stomatal bands in the middle portion of a leaf; that on the left belongs to the upper surface, the other two belong to the lower surface. $\times 50$. Slide *b*, prepared from specimen V.17511.
- FIG. 11. Cuticle from the apex of the upper surface, showing two stomatal bands. $\times 50$. Slide *a*, prepared from specimen V.17511. A fragment only of the figured preparation remains: the bulk of it was destroyed after photographing, in an attempt to treat it with hydrofluoric acid.
- FIG. 12. Cuticle of the upper surface showing part of a stomatal band. $\times 50$. Prepared from V.15208, a specimen figured by

Gardner (1888, pl. iii, fig. 34). Preparation in the Collection of the Palaeobotanical Department, Riksmuseet, Stockholm, Sweden.

- FIG. 13. Cuticle of the upper surface. $\times 550$. Slide V.17511b, cf. fig. 10 above. At the base there is a stoma surrounded by four subsidiary cells. The papillae (?) on the epidermal cells are also clearly seen.
- FIG. 14. A single stoma with six subsidiary cells. $\times 550$. V.17511.
- FIG. 15. A single stoma with five subsidiary cells. $\times 550$. V.17511. Figs. 14 and 15 both show the guard cells.
- FIG. 16. An epidermal cell showing irregular papillae (?). $\times 1575$. V.17511.

Doliosstrobilus sp. (*Araucarites gurnardi* ?), p. 52.

- FIG. 17. A cone-scale; impression of the upper surface. $\times 2$. V.17514.
- FIG. 18. Part of a similar scale; impression of lower surface. $\times 2$. V.17515.
- FIG. 19. An isolated seed of Araucarian type (impression), with asymmetric, lateral wing. $\times 3$. V.17516.

Pinus sp. 1, p. 54.

- FIG. 20. An impression of the wing of an abortive seed. $\times 3$. V.17517.

Pinus sp. 2, p. 55.

- FIG. 21. Impression of a group of needles. $\times 1$. V.17016.
- FIG. 22. A part of one needle magnified to show the impressions of the stomata. $\times 18$ approx. V.17016.

Pityospermum ambiguum n. sp., p. 55.

- FIG. 23. Impression of winged seed. $\times 3$. V.17518.

PLATE III

Cupressus sp., p. 57.

- FIG. 1. Cast of the inner surfaces of four basal scales of the cone. $\times 3$. V.17519.
- FIG. 2. Cast of the inner surfaces of the apical scales of the cone (to the right below), of a median scale (in shadow above). The small aperture (to the left below) leads into another hidden median scale. $\times 3$. V.17519.

Libocedrus sp. ? p. 58.

- FIG. 3. Impression of a fragment of twig, showing two whorls of leaves, with the bases of a pair of branches in the axils of the upper whorl. $\times 6$. V.17520.

Typha latissima Al. Br., p. 60.

- FIG. 4. A typical block of fragmentary leaves. Two fragments to the left show external impressions only, one to the right shows an internal cast of the lacunae superimposed on the external impression. $\times 1$ approx. V.17521.
- FIG. 5. A single leaf fragment, part external impression, part internal cast. It shows the form of the transverse section of the leaf. $\times 1$ approx. V.17522.

- FIG. 6. A fragment of a leaf (internal cast) to show the delicate lace-like diaphragms which divide the lacunae transversely. The figure shows three lacunae in transverse section. $\times 12$. V.17523.
- FIG. 7. A portion of a stem with sheathing leaf bases. $\times 2$. V.17524.
- FIG. 8. An impression of a fruit with long style and stalk. Dark organic blotches can be seen adhering to the surface. $\times 12$. V.17525.
- FIG. 9. An impression of a fruit with style and stalk enclosing an organic seed in the position of life. The micropylar cap can be seen at the apex. $\times 24$. V.17526.
- FIG. 10. Three groups of seeds, lying in the matrix. $\times 6$. V.17527.
- FIG. 11. A single seed isolated from the matrix. $\times 24$. V.17528.

Sparganium multiloculare n. sp., p. 63.

- FIG. 12. The external impression of a fruit, lateral view, enclosing the internal casts of the four locules of the endocarp. $\times 4$. V.17529.
- FIG. 13. The external impression of an endocarp, and the internal casts of its five locules, viewed from above. The micropylar plug can be seen adhering to the apices of three of the casts. $\times 4$. V.17530.
- FIG. 14. An isolated five-loculed endocarp, lateral view. Three apertures of styler canal and micropyle are clearly visible at the apex. $\times 6$. V.17531.
- FIG. 15. The same endocarp, basal view. $\times 4$. V.17531.
- FIG. 16. Longitudinal section through three locules of an endocarp lying in the matrix. The styler canals and micropylar apertures of two locules are clearly seen at the apex, and at the bases of the locules the chalazal scars are visible. $\times 6$. V.17532.
- FIG. 17. Longitudinal section through two locules of an endocarp, removed from the matrix. $\times 12$. V.17533.
- FIG. 18. Leaf impression, probably of *Sparganium multiloculare*. $\times 1$. V.17534.

Potamogeton pygmaeus Chandler, p. 66.

- FIG. 19. A group of fruits (casts) showing the mode of occurrence in the Insect Limestone. A few casts of *Limnocarpos spinosus* can also be seen. $\times 6$. V.17535.
- FIG. 20. A fruit, showing the spines along the dorsal margin from apex to base. $\times 12$. V.17536.
- FIG. 21. An impression of a fruit showing the recurved style, median ventral spine, and long forked basal spines. $\times 12$. V.17537.
- FIG. 22. An endocarp lying in the matrix. It shows cell-structure. $\times 30$. V.17538.

Potamogeton pygmaeus ? p. 67.

- FIG. 23. A ligulate leaf (impression). $\times 4$. V.17539.
- FIG. 24. An oval leaf (impression) with somewhat auricled base and more numerous longitudinal nerves than the preceding. $\times 4$. V.17540.

PLATE IV

Limnocarpus headonensis (Gardner), p. 70.

- FIG. 1. Carpel, and internal calcite cast of the locule and vascular canal. The white dotted line on the right marks the limit of the locule on that side (obscured by shadow). $\times 12$. V.17541.
- FIG. 2. Exterior of carpel showing style and lateral depression. $\times 12$. V.17542.
- FIG. 3. Exterior of a carpel, dorsal view, showing germination valve. $\times 12$. V.17543.

Limnocarpus spinosus n. sp., p. 71.

- FIG. 4. Interior of endocarp. $\times 12$. V.17544.
- FIG. 5. Group of carpels (external casts). $\times 6$. V.17545.
- FIG. 6. Fruit (showing two spines on ventral margin), broken longitudinally to show the internal cast of the locule within. $\times 12$. V.17546.
- FIG. 7. Endocarp, dorsal view, showing germination valve. $\times 12$. V.17547.
- FIG. 8. Same endocarp, lateral view. $\times 12$. V.17547.

Potamogeton sp. ? p. 68.

- FIG. 9. Stem with crowded leaves (impression). $\times 2$. V.17548.

Najas oligocenica n. sp., p. 72.

- FIG. 10. Seed (inverted in figure). $\times 24$. V.17549.

Ottelia brittanica n. sp., p. 73.

- FIG. 11. Impression of two fruits showing spathe and calyx segments. $\times 4$. V.17007.
- FIG. 12. Impression of single fruit showing the wings on the spathe. $\times 6$. V.17550.

Stratiotes neglectus Chandler, p. 74.

- FIG. 13. Exterior of seed. $\times 6$. V.17551.
- FIG. 14. Interior of same seed showing micropyle and raphe. $\times 6$. V.17551.

Gramineae, p. 75.

- FIG. 15. Sp. 1. Portion of a large leaf (impression). $\times \frac{2}{3}$. V.17552.
- FIG. 16. Sp. 1. Impression of another specimen showing nervation. $\times 6$. V.17553.
- FIG. 17. Sp. 2. Leaf impression with tip complete. $\times \frac{1}{2}$. V.17554.
- FIG. 18. Sp. 3. Cataphyll, impression. $\times 2$. V.17555.

Carex gurnardi n. sp., p. 77.

- FIG. 19. Seed. $\times 24$. V.17556.

Cyperaceae. Utricle of *Carex* ? p. 77.

- FIG. 20. Impression. $\times 3$. V.17557.
- FIG. 21. Impression of counterpart. $\times 6$. V.17557.

Cladiocarya foveolata n. gen. & sp., p. 77.FIG. 22. Exterior of endocarp. $\times 12$. V.17558.FIG. 23. Exterior of same endocarp, showing lateral ridge (view at right angles to that in fig. 22). $\times 12$. V.17558.*Epipremnum ornatum* n. sp., p. 83.FIG. 24. Seed, broken at chalaza and micropyle, showing the external form. $\times 12$. V.17559.FIG. 25. Seed, external impression showing cast of micropylar aperture and of the concentric pits on the surface. $\times 15$. V.17559.*Sabal major* (Unger), p. 79.FIG. 26. Impression of upper surface of frond. $\times 1$. V.17560.*Palmophyllum* sp., p. 80.FIG. 27. Impression of upper surface of a frond and counterpart representing a tiny fragment of the lower surface. $\times 1$. V.17561.

PLATE V

Palaeothrinax Mantelli n. gen. & sp., p. 80.FIG. 1. Leaf, impression of upper surface. $\times \frac{3}{10}$. 38358.FIG. 2. Same leaf, junction of petiole and lamina to show the impression of the ligule. $\times 1$. 38358.

FIG. 3. Outline drawing in explanation of fig. 2.

FIG. 4. Part of another leaf. $\times 1$. V.1848. The triangular rachis can be seen, but a break in the organic substance, and a shadow, make it appear longer than is actually the case. The dark line at the top of the petiole, convex upwards, represents the ligule where it arises from the petiole; it can only be seen where the organic substance of the leaf is chipped away, revealing the underlying impression of the upper surface.

FIG. 5. Diagrammatic outline drawing in explanation of fig. 4.

Spirematospermum Wetzleri (Heer), p. 84.FIG. 6. Seed lying in matrix; the hilum is seen below. $\times 6$. V.17562.FIG. 7. Broken seed showing spiral striations clearly. $\times 6$. V.17563.*Costus* sp. ? p. 85.FIG. 8. Impression of a leaf fragment. $\times 2$. V.17564.FIG. 9. Fragment of a second leaf showing nervation. $\times 12$. V.17565.*Zingiberaceae* Genus ? p. 86.FIG. 10. Fragment of leaf, impression of lower surface. $\times \frac{4}{5}$ approx. V.17566.FIG. 11. Counterpart of the above, impression of upper surface. $\times \frac{4}{5}$ approx. V.17566.*Monocotylophyllum* sp., p. 87.FIG. 12. Leaf impression. $\times 2$. V.17567. The apparent triangular junction of lamina and petiole is misleading and due to secondary deposition of mineral matter.

PLATE VI

Engelhardtia macroptera (Brongniart), p. 87.

- FIG. 1. Impression of involucre, showing four lobes. $\times 2$. V.17012.
 FIG. 2. Impression showing complete dorsal lobe, and parts of three other lobes of the involucre; also impression of fruit and of three of the perianth segments. $\times 2$. V.17568.
 FIG. 3. Impression of mature fruit, lying between the dorsal and ventral lobes of the involucre. $\times 2$. V.17569.
 FIG. 4. Detached discoid gland mounted in glycerine (upper surface). $\times 158$. Slide *a* from V.17570.
 FIG. 5. Another gland similarly treated showing the lower surface $\times 158$. Slide *a* from V.17570.

Engelhardtia sp. 2, p. 93.

- FIG. 6. Impression of dorsal lobe of involucre, showing glands (appearing as dots). $\times 2$. V.17571.

Hooleyia Hermis (Unger), p. 93

- FIG. 7. Impression showing superior perianth segments on either side of the two stigmas and a portion of the body and wings. $\times \frac{3}{2}$. V.17015.
 FIG. 8. Impression to show the two wings and the general form. $\times 2$. V.17014.
 FIG. 9. Impression showing nervation on the body of the fruit, the surface of which is thickly beset with discoid glands. $\times 3$. V.17572.

Carpinus sp., p. 96.

- FIG. 10. Fruit showing perianth segments above. $\times 3$. V.17573.

Fagus sp. ? p. 96.

- FIG. 11. Leaf impression. $\times 1$. V.17574.

Quercus sp. ? p. 97.

- FIG. 12. Impression of nut. $\times 3$. V.17575.

Ficus sp., p. 97.

- FIG. 13. Impression of leaf, lower surface. $\times 1$. V.17576.
 FIG. 14. Counterpart of the above (petiole and base) showing impression of upper surface. $\times 2$. V.17576.

Brasenia ovula (Brongniart), p. 99.

- FIG. 15. Mass of seeds (impressions and internal casts) lying in matrix. $\times 11$ approx. V.17577.
 FIG. 16. A single seed. $\times 12$. V.17578.
 FIG. 17. Internal cast of a seed. $\times 6$. V.17579.
 FIG. 18. Surface of seed to show cell structure. $\times 30$. V.17580.

Aldrovanda vesiculosa Linn., p. 112.

- FIG. 19. External surface of seed. $\times 12$. V.17483. From the interglacial peat of Galitsch near Moscow.
 FIG. 20. Interior of another seed showing two seed-coats and the lining of the seed-cavity. $\times 12$. V.17484. From same locality.

- FIG. 21. Exterior of a seed. $\times 12$. From the Amber-pine beds of Denmark, Collection Danish Geological Survey.
- FIG. 22. Interior of a second seed, showing the inner surface of the outer seed-coat. From the Amber-pine beds of Denmark, Collection Danish Geological Survey.
- FIG. 23. The inner seed-coat, composed of columnar cells, from the specimen in fig. 22. $\times 12$. Collection Danish Geological Survey.

Aldrovanda ovata (Chandler), p. 113.

- FIG. 24. Exterior of seed, showing raphe. $\times 12$. V.17485. Lower Headon of Hordle.
- FIG. 25. Interior of another seed, showing the two seed-coats. $\times 12$. V.17486. Lower Headon of Hordle.
- FIG. 26. Inner seed-coat removed from the outer, and viewed from the exterior. $\times 12$. V.17487. Lower Headon of Hordle.

Aldrovanda intermedia n. sp., p. 113.

- FIG. 27. Seed, with outer coat partially removed to show the inner. $\times 12$. V.17581.
- FIG. 28. Exterior of seed, showing embryotega and micropyle within it. $\times 12$. V.17582.
- FIG. 29. Exterior of seed attached to matrix, showing raphe. $\times 12$. V.17582.

Hydrocharis morsus-ranae Linn., p. 112.

- FIG. 30. Seed for comparison with *Aldrovanda*. $\times 12$. Collection of the Danish Geological Survey.

Clematis vectensis n. sp., p. 101.

- FIG. 31. Impression of an awned fruit. $\times 3$. V.17583.
- FIG. 32. Impression of a narrower fruit. $\times 3$. V.17584.
- FIG. 33. Impression of fruit, showing marginal rim and cell structure. $\times 6$. V.17585.

PLATE VII

Ranunculus heterostylus n. sp., p. 103.

- FIG. 1. Endocarp showing ventral corky margin and striate surface. $\times 24$. V.17586.
- FIG. 2. Impression of achene with style at right angles to the ventral margin. $\times 12$. V.17587.
- FIG. 3. Impression of achene with style in line with the ventral margin. $\times 12$. V.17588.
- FIG. 4. Impression of achene with part of the seed lying within. The cell structure of the seed can be seen. $\times 24$. V.17013.

Cinnamomum lanceolatum (Unger), p. 105.

- FIG. 5. Leaf impression (lower surface). $\times 2$. V.17589.
- FIG. 6. Leaf impression, showing base and petiole, almost certainly of this species. $\times 2$. V.17590.
- FIG. 7. Cuticle, lower surface, showing hair bases and stomata; obtained from leaf fragment in fig. 6. $\times 158$. V.17590a.

- FIG. 8. Cuticle, upper surface, from the same leaf. $\times 158$. V.17590a.
Cinnamomum pedunculatum Nees var. *angustifolium* Hemsl., p. 106.
 FIG. 9. For comparison with the fossil. $\times 1$. Recent. Kew Herbarium.

Cinnamomum Scheuchzeri Heer, p. 107.

- FIG. 10. Leaf impression, upper surface. $\times 1$ V.17591.
 FIG. 11. Fragment of cuticle from the margin of the above leaf. $\times 68$.
 V.17591a.
 FIG. 12. Cuticle from the upper surface of the same leaf, near the
 margin. $\times 68$. V.17591b.

Neolitsea sp., p. 109.

- FIG. 13. Impression of broken leaf, with much organic substance. $\times 1$.
 V.17592.
 FIG. 14. Cuticle of lower surface of the same leaf. $\times 68$. V.17592a.
 It shows the grouping of the stomata in relation to the fine
 nervation.
 FIG. 15. Cuticle of lower surface to show the stomata. $\times 158$. V.17592b.
 FIG. 16. Cuticle of upper surface. $\times 68$. V.17592b.

Cruciferae ? p. 110.

- FIG. 17. Impression of the valve of a fruit ? $\times 4$. V.17593.

Papaver pictum n. sp., p. 111.

- FIG. 18. Seed, basal view, showing sculpture. $\times 24$. V.17594.
 FIG. 19. Same seed, lateral view (inverted). $\times 24$. V.17594.

Zanthoxylon (?) *costatum* n. sp., p. 114.

- FIG. 20. Seed, lateral view. $\times 6$. V.17595.
 FIG. 21. Same seed, ventral view, with much of testa removed to show
 internal cast. $\times 12$. V.17595.

Zizyphus paradisiacus (Unger) var. *paradoxus* nov., p. 115.

- FIG. 22. Impression of leaf, upper surface. $\times 2$. V.17018.
 FIG. 23. Impression of leaf, lower surface. $\times 2$. V.17018.

PLATE VIII

Rhamnospermum bilobatum Chandler, p. 117.

- FIG. 1. Dorsal view of seed lying in matrix, showing two lobes. $\times 6$.
 V.17596.
 FIG. 2. Basal view of seed lying in matrix, showing large micropyle.
 $\times 6$. V.17597.

Apocynospermum striatum n. gen. & sp., p. 118.

- FIG. 3. Impression of seed with pappus. $\times 4$. V.17598.

Apocynospermum rostratum n. sp., p. 119.

- FIG. 4. Impression of seed. $\times 6$. V.17599.

Apocynospermum elegans n. sp., p. 120.

- FIG. 5. Impression with organic remains of a seed with pappus,

showing hilum, and the light-coloured granular substance representing endosperm. $\times 3$. V.17600.

- FIG. 6. Impression of a second seed with pappus, and much of the testa preserved. $\times 6$. V.17601.

Apocynospermum dubium n. sp., p. 121.

- FIG. 7. Impression of seed with pappus. $\times 12$. V.17602.

Phyllanthera vectensis n. sp., p. 122.

- FIG. 8. Impression of seed and pappus with remains of testa, and granular substance representing endosperm. $\times 6$. V.17603.

- FIG. 9. Impression of seed with pappus, showing linear median raphe. $\times 6$. V.17604.

- FIG. 10. Counterpart of preceding, showing much of the actual testa. $\times 4$. V.17604.

- FIG. 11. Cell structure of testa. $\times 30$. V.17605.

Phyllanthera perakensis King & Gamble, p. 123.

- FIG. 12. Seed. $\times 6$. Recent. Kew Herbarium.

Tylophora antiqua n. sp., p. 123.

- FIG. 13. Impression of ventral surface showing raphe. $\times 3$. V.17606.

Tylophora hirsuta Wight, p. 124.

- FIG. 14. Seed, ventral surface. $\times 3$. Recent, Kew Herbarium.

Melissa parva n. sp., p. 126.

- FIG. 15. Seed, lateral view showing form and basi-lateral attachment scar. $\times 12$. V.17607.

- FIG. 16. Same seed, base, showing attachment. $\times 18$. V.17607.

Ajuginucula Smithii n. sp., p. 127.

- FIG. 17. Seed, ventral face, showing large scar of attachment. $\times 12$. V.17608.

- FIG. 18. Same seed, outer face, showing sculpture. $\times 30$. V.17608.

Catalpa rugosa n. sp., p. 128

- FIG. 19. Winged seed; impression of ventral surface. $\times 3$. V.17609.

Radermachera pulchra n. sp., p. 129.

- FIG. 20. Impression of winged seed, ventral surface. $\times 3$. V.17610.

Radermachera glandulosa Miq., p. 130.

- FIG. 21. Seed, ventral surface. $\times 3$. Recent, Kew Herbarium.

Incarvillea pristina n. sp., p. 130.

- FIG. 23. Seed, ventral face showing hilum at base; part impression and part organic substance. $\times 6$. V.17611.

- FIG. 24. Same seed to show curvilinear arrangement of cells on testa. $\times 12$. V.17611.

Incarvillea grandiflora Bureau & Franchet, p. 131.

- FIG. 25. Seed, ventral side. $\times 6$. Recent, Kew Herbarium.

Acanthus rugatus n. sp., p. 131.FIG. 26. Impression of seed. $\times 3$. V.17612.FIG. 27. Counterpart of preceding. $\times \frac{3}{2}$. V.17612.*Acanthus ilicifolius* Linn., p. 132.FIG. 28. Seed. $\times 2$. Recent, Kew Herbarium.*Abelia quadrialata* n. sp., p. 133.FIG. 29. Impression of four wings. $\times 2$. V.17613.FIGS. 30 Counterpart impressions of fruit showing body, and two of the
& 31. wings. $\times 2$. V.17614.*Abelia quinquealata* n. sp., p. 135.FIG. 32. Impression of wings, upper surface. $\times 4$. V.17615.FIG. 33. Impression of wings of a second specimen (lower surface).
 $\times 4$. V.17616.*Abelia spathulata* Sieb. & Zucc., p. 136.FIG. 34. Fruit showing wings and body. $\times 2$. Recent, Yokohama
Nursery Company.

PLATE IX

Abelia trialata n. sp., p. 136.FIG. 1. Impression of two specimens, one showing the body of the
fruit, and both showing two of the three wings. $\times 2$. V.17617.FIG. 2. Impression of the upper surface of the wings, showing nervation,
one wing almost perfect. $\times 2$. V.17618.FIG. 3. Impression of the lower surface of another whorl of wings,
showing the nervation, less prominent on this surface, and
the characteristic centre. $\times 2$. V.17619.*Abelia corymbosa* Regel & Schmal., p. 137.FIG. 4. One of the wings and the body of a fruit, for comparison with
the fossil. $\times 2$. Recent, Kew Herbarium.*Abelia Graebneriana* Rehd., p. 138.FIG. 5. Immature fruit, showing body and three wings. $\times 2$. Recent,
Kew Gardens.*Abelia* sp., p. 138.FIG. 6. Impression of wings (lower surface); one wing nearly perfect.
 $\times 2$. V.17620.*Dipelta europaea* n. sp., p. 139.FIG. 7. Impression of two large dorsal bracts and of the fruit lying
upon them. $\times 3$. V.17621.FIG. 8. Same specimen, counterpart; impression of the small triangular
ventral bract and beyond it that of the large dorsal bracts.
 $\times 3$. V.17621.FIG. 9. Impression of dorsal side of a fruit showing the two large
bracts and the stalk. The stain in the surrounding matrix
gives an approximate idea of the original form and size of
these two wings. $\times 3$. V.17622.

Dipelta yunnanensis Franch., p. 140.

- FIG. 10. For comparison with the fossil, position as in fig. 8. $\times 2$.
Recent, Kew Herbarium.

Compositae genus ? p. 141.

- FIG. 11. Seed and impression of pappus. $\times 3$. V.17623.

Flabelllicula anglica n. gen. & sp., p. 142.

- FIG. 12. Impression of winged fruit. $\times 6$. V.17624.
FIG. 13. Impression of a second specimen. $\times 6$. V.17625.

Samaravectis ovalis n. gen. & sp., p. 142.

- FIG. 14. Impression of winged fruit showing pedicel. $\times 4$. V.17626.
FIG. 15. A second impression showing the style (a groove at the apex in the impression). The wing is delimited from the body of the fruit by a crack in the stone. $\times 4$. V.17627.
FIG. 16. Impression of wing, and internal cast of fruit. $\times 4$. V.17628.

Carpolithus actinidiformis n. sp., p. 143.

- FIG. 17. Seed lying in matrix. $\times 12$. V.17629.

Carpolithus sp. 2, p. 143.

- FIG. 18. Fruit, casts and fragment of endocarp wall. $\times 2$. V.17630.

Carpolithus sp. 3, p. 144.

- FIG. 19. Fruit, external impression and internal casts of a row of seeds or locules. $\times 3$. V.17631.
FIG. 20. External impression of a second specimen. $\times 3$. V.17632.
FIG. 21. Actual carpel- or seed-wall removed from specimen. $\times 6$. V.17632.
FIG. 22. The same, from the opposite side, showing germination valves. $\times 6$. V.17632.

Carpolithus sp. 4, p. 145.

- FIG. 23. Fruit or seed. $\times 3$. V.17633.

Carpolithus sp. 5, p. 145.

- FIG. 24. External impression of the apex of a lobed fruit. $\times 6$. V.17634.

Carpolithus sp. 6, p. 146.

- FIG. 25. Exterior of large, thick-walled, woody endocarp. $\times 12$. V.17635.
FIG. 26. Interior of same endocarp, showing locule and canal at apex communicating with the exterior. $\times 6$. V.17635.

Carpolithus sp. 7, p. 146.

- FIG. 27. Impression of an infundibular calyx. $\times 6$. V.17636.

Carpolithus sp. 8, p. 147.

- FIG. 28. Impression of another infundibular calyx of a different species. $\times 12$. V.17637.

Carpolithus sp. 9, p. 147.

- FIG. 29. Exterior showing apex with large canal, surrounded by four small ones. $\times 6$. V.17638.

FIG. 30. Same endocarp, showing the base. $\times 6$. V.17638.

FIG. 31. A second endocarp (fragment) showing the interior, broken longitudinally through the apical canal, and one of the small canals. $\times 6$. V.17639.

PLATE X

Carpolithus sp. 10, p. 148.

FIGS. 1 Impressions (counterparts) of a fruit surrounded by staining
& 2. in the matrix. $\times 4$. V.17640.

Carpolithus sp. 11, p. 148.

FIGS. 3 Counterpart impressions of the bracts of a fruit with some
& 4. organic remains. $\times 2$. V.17021.

Carpolithus sp. 12, p. 149.

FIG. 5. Impression of the wing of a fruit. $\times 3$. V.17641.

Carpolithus sp. 13, p. 150.

FIG. 6. Impression of the inner face of the valve of a pod. $\times 2$. V.17642.

Carpolithus sp. 14, p. 150.

FIG. 7. Seed. $\times 20$. Keeping Collection, Sedgwick Museum, Cambridge. Similar seeds, in fruits with long pedicels, are represented in figs. 8 & 9. In fig. 8 the fruits can be seen scattered over the surface of the stone. Fig. 9 (part of the same stone more highly magnified) shows the fruit and seed of *Carpolithus* sp. 14 to the right. There is probably no organic connexion with the leaf.

Dicotylophyllum pinnatifidum n. sp., p. 151.

FIG. 8. Carbonaceous leaves lying in a soft marly matrix. Also fruits of *Carpolithus* sp. 14. $\times 2$. Keeping Collection, Sedgwick Museum, Cambridge.

FIG. 9. Part of a leaf represented in fig. 8. $\times 6$. Keeping Collection, Sedgwick Museum, Cambridge. A fruit and seed of *Carpolithus* sp. 14 is seen to the right.

FIG. 10. Impression of lower surface of a leaf showing nervation. The edges tended to become inrolled. $\times 4$. V.17643.

FIG. 11. Fragment of an actual leaf magnified to show nervation and thin hyaline margin (broken away in parts). $\times 12$. Keeping Collection, Sedgwick Museum, Cambridge.

FIG. 12. Cuticle. Fragment from the upper surface. $\times 68$. V.17644a.

Dicotylophyllum sp. 2, p. 154.

FIG. 13. Impression of a leaf, base broken but completed in figure by using a reverse print of its counterpart. $\times \frac{3}{2}$. V.17645.

FIG. 14. The counterpart showing the base (correctly printed). $\times \frac{3}{2}$. V.17645.

Dicotylophyllum sp. 3, p. 155.

FIG. 15. Impression of the base of a leaf, and its petiole. $\times 2$. V.17646.

Dicotylophyllum sp. 4, p. 155.

FIG. 16. Impression of a leaf, lower surface. The apex is drawn from the counterpart, on which it is preserved. $\times 1$. V.17009.

Dicotylophyllum sp. 5, p. 156.

FIG. 17. Impression of a leaf, lower surface. $\times \frac{9}{10}$. V.17647.

Dicotylophyllum sp. 6, p. 157.

FIG. 18. Impression of a spiny leaf, lower surface. A third long spine passes into the crack across the stone shown in the photograph, and a fourth passes down into deep shadow on the left towards the base. $\times 1$. V.17648.

Dicotylophyllum sp. 7, p. 157.

FIG. 19. Impression of a leaf, lower surface. $\times \frac{8}{9}$. V.17649.

Dicotylophyllum sp. 8, p. 157.

FIG. 20. Impression of two lobes of a palmate leaf. $\times 2$. V.17650.

PLATE XI

Dicotylophyllum sp. 9, p. 158.

FIG. 1. Impression of skeletonised leaf, apex and base incomplete. $\times 2$. V.17651.

Dicotylophyllum sp. 10, p. 158.

FIG. 2. Impression of lower surface of leaf-fragment with sigmoidal teeth along the margin. $\times 2$. V.17652.

Dicotylophyllum sp. 11, p. 158.

FIG. 3. Impression of upper surface of a leaf, base imperfect. $\times 2$. V.17653.

Dicotylophyllum sp. 12, p. 159.

FIG. 4. Impression of lower surface of a leaf. $\times 2$. V.17654.

Dicotylophyllum sp. 13, p. 160.

FIG. 5. Impression of lower surface of long lanceolate leaf with sigmoidal teeth. $\times 2$. V.17655.

Dicotylophyllum sp. 14, p. 160.

FIG. 6. Leaf impression, base drawn from counterpart. $\times 2$. V.17656.

Dicotylophyllum sp. 15, p. 160.

FIG. 7. Impression of a skeletonised leaf. $\times 2$. V.17657.

Dicotylophyllum sp. 16, p. 161.

FIG. 8. Impression of a leaf attached to a twig. $\times 4$. V.17658.

Sepal ? p. 161.

FIG. 9. Impression of sepal or bract. $\times 3$. V.17659.

Phyllites sp., p. 161.

FIG. 10. Original appearance of specimen showing the impression of a row of fructifications on either side of the axis. $\times 3$. V.17660.

- FIG. 11. Appearance of specimen after the removal of the right-hand row, showing the impression underneath of a lamella which was in continuity with the fruits or seeds. $\times 3$. V.17660.

Roots and Scars, pp. 163, 164.

- FIG. 12. Impression of a single root. $\times 2$. V.17661.
 FIG. 13. Impression of a group of three roots with rootlets. $\times 2$. V.17662.
 FIG. 14. Impression of a root with rootlets. $\times 1$. V.17663.
 FIG. 15. External impression of rhizome with a bud given off above the node and roots below. $\times 1$. V.17664.
 FIG. 16. Internal cast of a rhizome, several nodes. $\times 1$. V.17665.
 FIG. 17. Impression of unknown scar. $\times 2$. V.17666.
 FIG. 18. Impression of scar or nodal diaphragm. $\times 2$. V.17667.
 FIG. 19. Impression of unknown scar. $\times 2$. V.17668.
 FIG. 20. Impression of unknown scar. $\times 2$. V.17669.

Cuticles of unknown dicotyledonous leaves, p. 164.

- FIG. 21. Lower surface showing stomata. $\times 158$. From rock specimen, V.17670.
 FIG. 22. Upper surface of same leaf fragment. $\times 68$. From rock specimen V.17670.
 FIG. 23. Upper surface of another completely isolated leaf fragment. $\times 158$. Slide V.17671a.
 FIG. 24. Lower surface with stomata of the same leaf fragment. $\times 158$. V.17671b.

PLATE XII

See pp. 165-173.

- FIG. 1. *Chara tuberculata* Lyell. A'Court Smith Collection, V.18320.
 FIG. 2. *Chara vectensis* n. sp. A'Court Smith Collection, V.18321.
 FIG. 3. *Chara subglobosa* n. sp. Whitecliff Bay, V.18331.
 FIG. 4. *Chara medicaginula* (Lamarck). Osborne Beds, King's Quay, V.18329.
 FIG. 5. *Chara vespiformis* n. sp. Bembridge Foreland, V.18326.
 FIG. 6. *Chara helicteres* Brongn. Bembridge Foreland, V.18330.
 FIG. 7. *Chara vespiformis*? Bembridge Foreland, V.18327.
 FIG. 8. *Chara vectensis* n. sp. A'Court Smith Collection, V.18321.
 FIG. 9. *Chara vasiformis* Reid & Groves. Saltmead Ledge, V.18332.
 FIG. 10. *Chara* sp. Stem node, section of base, V.18333d.
 FIG. 11. " " Portion of corticate stem (haplostichous), V.18333h.
 FIG. 12. " " Portion of ecorticate stem, V.18333i.
 FIG. 13. " " Stem node, side view, V.18333b.
 FIG. 14. " " The same node seen diagonally from below, showing stipulodes, V.18333b.
 FIG. 15. " " Transverse section of stem, V.18333a.
 FIG. 16. " " Portion of corticate stem (apparently diplostichous), V.18333j.

All $\times 15$.

INDEX

The number of the page on which a genus or species is particularly described is printed in **clarendon** type.

An asterisk indicates a text figure.

Names of genera and species are in *italics*, of other systematic groups in roman type.

Abelia, 3, 6, 8, 11, 12, **132**
chinensis, 133, 134, 136
corymbosa, 133, 137, 138; Pl. IX,
 fig. 4
Graebneriana, 132, 138; Pl. IX,
 fig. 5
insularis, 137
quadrialata, 103, **133**, 134*;
 Pl. VIII, figs. 29-31
quinquealata, **135***, 136; Pl.
 VIII, figs. 32, 33
serrata, 134, 136
spathulata, 133, 134, 136; Pl.
 VIII, fig. 34
 sp. 4, **138**, 139*; Pl. IX, fig. 6
trialata, 133, **136**, 137*; Pl. IX,
 figs. 1-3
umbellata, 137
Zanderi, 137
 Abietineae, 53
 Acanthaceae, 131
Acanthopanax, 24
Acanthus, 8, 12, 29, 131, 156
ebracteatus, 132
ilicifolius, 131, 132; Pl. VIII,
 fig. 28
rugatus, 11, **131**; Pl. VIII,
 figs. 26, 27
volubilis, 131, 132
Acer, 9, 23, 24
Acerates, 124
longifolia, 124
veterana, 124
 A'COURT SMITH. See SMITH.
Acrostichites, 35
 sp., 34
Acrostichum, 3, 4, 12, 29, 33
aureum, 29, 34-36, 132
hesperium, 36
Lanzaeanum, 11, **33**, 34*-36,
 132; Pl. I, figs. 1-5
Actinidia, 143

Actinostrobus, 59
Adiantum, 37
 African alliance, 15-18
Agathis, 53
 Aix-en-Provence, 25, 26, 28, 35, 82,
 129
Ajuga, 127
Ajuginucula, 6, 12, **127**
Smithii, 11, **127**; Pl. VIII,
 figs. 17, 18
 Ajugoideae, 127
 Alais, 51, 53
Aldrovanda, **111**
intermedia, 11, **113**; Pl. VI,
 figs. 27-29
ovata, **113**; Pl. VI, figs. 24-26
vesiculosa, 112, 113; Pl. VI,
 figs. 19-23
Alyssum, 110
 Amber Beds, 25, 28
 Amber-Pine Beds, 63, 112
 American flora, 13-18
Amomum, 74, 86
Ampelopsis, 27
 Anacardiaceae, 138
Andromeda, 27
Aneimia oblongifolia var. *lanosa*, 39
Anemone, 9, 102
 Angiospermae, 60
Anodendron, 120, 125
 Anonaceae, 145
 Apocynaceae, 6, 7, 11, 12, 118, 124-
 126
Apocynospermum, **118**, 122
dubium, **121**; Pl. VIII, fig. 7
elegans, **120**, 123; Pl. VIII,
 figs. 5, 6
rostratum, **119**; Pl. VIII, fig. 4
striatum, **118**; Pl. VIII, fig. 3
Apocynum, 119
 Aquitanian, 28
 Araceae, 83

- Aralia*, 159
Araucaria, 50, 51
 Goepperti, 48, 50
 Araucarian seed, 53
 Araucarineae, 47
Araucarites, 2-4, 6, 7, 9, 47, 53, 56,
 57, 80
 Goepperti, 5, 50
 gurnardi, 5, 11, 26, 48-53; Pl. II,
 figs. 6-16
 peregrinus, 50
 Sternbergii, 48, 50
 Armissan, 25, 26, 28, 91
Arundinaria, 87
Arundo, 12, 76
 Asclepiadaceae, 12, 122, 124-126
Asclepias, 124
 spinosa, 124
 Asiatic flora, 13-18
 Asterales, 141
Athrotaxis, 56
 Couttsiae, 5, 56
 (?) *subulata*, 51
Azolla, 3, 6, 7, 9, 12, 30, 40, 62, 92,
 95, 103, 104
 caroliniana, 42
 filiculoides, 42
 filiculoides var. *rubra*, 42
 nilotica, 42
 pinnata, 42
 prisca, 11, 40*, 41*; Pl. I,
 figs. 14-23

 Bagshot Beds, 35
Bambusa, 12, 76
 Bambusae (?), 87
 BANDULSKA, H., 51, 151
Banksia, 6, 12, 152, 153
 serrata, 152
Bechera helicteres, 169
 medicaginata, 168
Beesia, 23
 Bembridge Foreland, 166
 Marl, 2-4
Berberis, 156
Betula, 23, 94
 Betulaceae, 96
Bidentites antiquus, 124
 Bignoniaceae, 8, 12, 128
 Bilin, 91, 99, 125
 Binstead, 170
Boehmeria, 142
 BOODLE, L., 42
Bougainvillea, 149
 Bournemouth, 35, 50, 51
 BOUSSAC, J., 4
 Bovey Tracey, 12, 25, 26, 28, 85,
 100
 Bracklesham, 54

Brasenia, 4-6, 8, 12, 99, 111, 112,
 153
 ovula, 11, 26, 99; Pl. VI, figs. 15-
 18
 BRISTOW, H. W., 5
 BRODIE, P. B., 1
Buchanania latifolia, 23
Bucklandia populnea, 23
 BULLOCK-WEBSTER, G., 170
 Burma, existing flora of, 13, 22

Caesalpinia, 159
 California, 42
Callitris, 59
 Brongniarti, 60
 Heeri, 60
 quadrivalvis, 60
 CAMPBELL, D. H., 30
 Caprifoliaceae, 132
Carduus, 156
Carex, 12, 77
 gurnardi, 11, 77; Pl. IV, fig. 19
 sp. 2, 77; Pl. IV, figs. 20, 21
Carpinus betulus, 96
 grandis, 87, 91
 laxiflora, 96
 macroptera, 87, 91
 oblonga, 87, 91
 producta, 87, 91
 sp., 11, 96; Pl. VI, fig. 10
 Turczaninowii, 96
Carpolithes Alleni, 149
 globulus, 100
 headonensis, 68, 70
 ovulum, 99, 100
 Wetzleri, 84
Carpolithus, 8, 27, 143
 actinidiformis, 143; Pl. IX, fig. 17
 globulus, 5
 Websteri, 5
 sp. 2, 143; Pl. IX, fig. 18
 sp. 3, 144, 163; Pl. IX, figs. 19-
 22
 sp. 4, 145; Pl. IX, fig. 23
 sp. 5, 145; Pl. IX, fig. 24
 sp. 6, 146; Pl. IX, figs. 25, 26
 sp. 7, 93, 146; Pl. IX, fig. 27
 sp. 8, 147; Pl. IX, fig. 28
 sp. 9, 147; Pl. IX, figs. 29-31
 sp. 10, 148; Pl. X, figs. 1, 2
 sp. 11, 148; Pl. X, figs. 3, 4
 sp. 12, 149; Pl. X, fig. 5
 sp. 13, 150; Pl. X, fig. 6
 sp. 14, 150; Pl. X, figs. 7-9
Carya, 23, 24
 cathayensis, 24
 tonkinensis, 24
Castanea, 97

- Catalpa*, 12, 128
Kaempferi, 128
ovata, 129
punctata, 129
rugosa, 11, **128**; Pl. VIII, fig. 19
Célas, 25, 26, 28, 36, 102, 138
Chamaecyparis, 59
Chamaecyparites, 58
Hardii, 58
Chamaerops, 82
Chara, 8, 11, 12, 101, 111, 167;
Pl. XII
Archiaci var. *tuberculata*, 170
Brongniarti, 169
delicatula, 170
Dutemplei, 169
helicteres, **169**; Pl. XII, fig. 6
medicaginula, 166, **167**, 168*, 169;
Pl. XII, fig. 4
onerata, 169
perpusilla, 166, **173***
sparnacensis, 169
subglobosa, **172**; Pl. XII, fig. 3
tuberculata, **170***; Pl. XII, fig. 1
vasiformis, 170, **171**; Pl. XII, fig. 9
vectensis, **172***; Pl. XII, figs. 2, 8
vespiformis, **171***; Pl. XII, figs.
5, 7
Wrightii, 168
Charophyta, 165
Chiavon, 51
Chilopsis, 128, 129
China, existing flora of, 13, 22-25
Chlorophora, 15, 17, 18
Chorisandra, 78
Chrysodium, 4
dilaceratum, 33, 35
Lanzaeanum, 5, 33, 34
minus, 33, 35
splendidum, 34, 35
Cinnamomum, 12, 105, 109
brevifolium, 106, 108
lanceolatum, 5, 11, 26, **105**, 106*,
107, 108; Pl. VII, figs. 5-8
pedunculatum var. *angustifolium*,
106; Pl. VII, fig. 9
polymorphum, 5, 108
Rossmässleri, 108
Scheuchzeri, 5, 11, 26, **107**, 108*;
Pl. VII, figs. 10-12
Wilsonii, 106
Cladocarya, 44, 77, 131
foveolata, 11, **77**; Pl. IV, figs. 22,
23
Cladium, 78
Cleghornia, 121
Clematis, 3, 6, 7, 9, 12, 67, 101, 103
heracleaefolia, 102
lasiantha, 102
tuberosa, 102
(Clematis) vectensis, 11, **101**, 134;
Pl. VI, figs. 31-33
Clerodendron serratum, 23
climate, 28
COCKERELL, T. D. A., 101
COLENUTT, G. W., 1, 2, 166
Compositae, 9, 12, 120-122, 124,
126, 141; Pl. IX, fig. 11
Comptonia dryandraefolia, 153
Coniferales, 47
Conites Goepfertii, 50
Copernicia, 80
Cornus, 24
Corylus, 97
Costus, 6, 85, 86
sp., 11, 85; Pl. V, figs. 8, 9
Cotoneaster, 24
Cromerian, 9, 17
Cruciferae, 110; Pl. VII, fig. 17
Cryptolepis, 122, 123
Cryptomeria Sternbergii, 51
Cupresseae, 59
Cupressineae, 57
Cupressus, 57, 59
Lawsoniana, 58
macrocarpa, 58
Pritchardi, 58
sp., 11, 57; Pl. III, figs. 1, 2
Curcuma, 86
cuticles, 164; Pl. XI, figs. 21-24
Cymaria, 127
elongata, 127
Cyperaceae, 77, 78
Cyperites Forbesii, 71
Cypselites, 12, 27, 124-126
costatus, 125
Regeli, 125
Cyrena pulchra, 3, 81
Daphnogene lanceolata, 105
Dicotyledones, 87
Dicotylophyllum, 151
pinnatifidum, 3, 5, 6, 11, 12, 150,
151; Pl. X, figs. 8-12
sp. 2, **154**; Pl. X, figs. 13, 14
sp. 3, **155**; Pl. X, fig. 15
sp. 4, **155**; Pl. X, fig. 16
sp. 5, **156**; Pl. X, fig. 17
sp. 6, **156**; Pl. X, fig. 18
sp. 7, 156, **157**; Pl. X, fig. 19.
sp. 8, **157**; Pl. X, fig. 20
sp. 9, **158**; Pl. XI, fig. 1
sp. 10, **158**; Pl. XI, fig. 2
sp. 11, **158**; Pl. XI, fig. 3
sp. 12, **159**; Pl. XI, fig. 4
sp. 13, **160**; Pl. XI, fig. 5
sp. 14, **160**; Pl. XI, fig. 6
sp. 15, **160**; Pl. XI, fig. 7
sp. 16, **161**; Pl. XI, fig. 8
spp., 161

- Didymochlaena*, 37
Dipelta, 8, 12, 139, 140
 elegans, 140
 europaea, 11, **139**; Pl. IX, figs. 7-9
 floribunda, 140
 ventricosa, 140
 yunnanensis, 140; Pl. IX, fig. 10
Diplostephanae, 167
Dipsaceae, 146
Dobinea, 149
Dodonaea, 149
Dodonaeites Decaisnei, 149
DOKTUROWSKY, W. S., 112
Doliosrobis, 3, 52
 Sternbergii, 2, 5, 48, 51, 53
 sp. **52**; Pl. II, figs. 17-19
Draba, 110
Droseraceae, 111
Dryandra, 6, 152, 153
Dulichium, 9, 112
 Dutch Pliocene flora, 13

Echites, 121
Echitonium superstes, 125
 endosperm, preservation of, 7
Engelhardtia, 3, 5, 6, 9, 12, 24, 62,
 87, 94, 146
 aceriflora, 91
 Brongniartii, 87, 88, 91
 decora, 87, 92
 javanica, 91
 macroptera, 11, 26, 44, **87**, 89*;
 Pl. VI, figs. 1-5
 nudiflora, 93
 nudiflora var. *crenata*, 91
 oxyptera, 88, 91
 parviflora, 91
 purpurea, 92
 serrata, 91
 simplicifolia, 91
 spicata, 90, 93
 sotzkiana, 87
 sp. 2, **93**; Pl. VI, fig. 6
 Wallichiana, 90, 91
Epipremnum, 6, 23, 83
 crassum, 83, 84
 giganteum, 83
 mirabile, 83
 ornatum, 11, **83**; Pl. IV, figs.
 24, 25
 pinnatum, 83
Equisetales, 44
Equisetum, 3, 4, 6, 9, 12, 44, 164
 giganteum, 44, 46
 lombardianum, 11, **44**; Pl. II,
 figs. 1-5
 procerum, 46
 robustum, 46
 sulcatum, 46

Eriocaulon sp., 68
 Etampes, 4
 ETTINGSHAUSEN, C. von, *passim*
 Euazolla, 30, 42

 Fagaceae, 96
Fagus, 12, 24, 96
 sp. ?, 11, **96**; Pl. VI, fig. 11
 fauna of Bembridge Marl, 4
Ficus, 5, 12, 23, 97, 98
 gibbosa, 99
 parietalis, 99
 sp., 11, **97**, 98*; Pl. VI, figs. 13,
 14
 urani, 99
 Filicales, 33
 Filices Incertae Sedis, 37-39; Pl.
 1, figs. 6-13
Fitzroya, 59
Flabellaria, 82
 Lamanonis, 26, 81, 82
 major, 79
Flabellulcula, 12, 141
 anglica, 11, **141**; Pl. IX, figs. 12,
 13
 FLORIN, R., 7, 47, 48, 53
 Flower (?), 165
Fokienia, 23, 59, 60
 Fontainebleau Beds, 4
 Foreland, Point, 81
Forsteronia, 121
Fortisia Lanzaeana, 33
Fortuneria, 23

 Galitsch, 112, 114
 Gard, 46
Gardenia, 85
 Wetzleri, 84
 GARDNER, J. S., *passim*
 Gergovie, 91
Geum, 102
Ginkgo, 150
Gleichenia, 5, 6, 12, 152
Globba, 86
Gomphocarpus, 124
Gomphoceras, 124
 Gramineae, 11, 12, 75, 76, 87;
 Pl. IV, figs. 15-18
 grass, 6
Grevillea, 152
 GROVES, J., 165
 Gurnard Bay, 2, 3
 Gurnard Ledge, 1, 3
 Gymnospermae, 47
Gyrogonites medicaginula, 167

 Hamstead, 52, 100, 166

- Hamstead Beds, 4, 29, 85, 169, 171
 Hamstead Ledge, 75, 166
 Häring, 25, 26, 28, 50, 51
 HARTZ, N., 29, 112
 Headon Beds, 4, 35, 68, 70, 85, 100, 113, 115, 118, 168, 169, 171, 173
 HEER, O., *passim*
Hemidesmus, 122
Heterocalyx, 12, 138
 Unger, 138
Hippocastanum, 97
Hiraea Hermis, 12, 93, 95
Holarrhena, 119, 125
 HOLLICK, A., 149
 HOOLEY, R. W., 2, 95
Hooleya, 3, 6, 8, 12, 44, **93**, 103
 Hermis, 11, 26, 30, **93**; Pl. VI, figs. 7-9
 Hordle, 12, 14-18, 21, 22, 25-29, 35, 66, 68, 85, 100, 113, 114, 118
Hydrocharis morsus-ranae, 112; Pl. VI, fig. 30
 Hydrocharitaceae, 73
 Hydropterideae, 40
Hypolytrum, 78

 Icacinaceae, 144
Ilex, 156
 horrida, 156
Incarvillea, 130, 131, 154
 compacta, 131
 grandiflora, 131; Pl. VIII, fig. 25
 olgae, 154
 pristina, 11, **130**; Pl. VIII, figs. 23, 24
 Insect Limestone, 3

 JUDD, J. W., 4
 Juglandaceae, 24, 30, 87
Juglans, 24
 regia, 24
 Jungermanniaceae, 152

Kickxia, 120
Koelreuteria, 149
Kolkwitzia, 23
 KORZHINSKY, S., 112

 Labiatae, 126, 147
 LAPPARENT, A. de, 4, 28
Latania, 80
 Lauraceae, 105
 LAURENT, L., 36, 102, 117, 138, 153

Leguminosites, 27
Leucothoe, 27
 Lewisham, 100
Libocedrus, 6, 58
 decurrens, 59, 60
 macrolepis, 24, 59, 60
 sp., 11, **58**; Pl. III, fig. 3
Limnocarpus, 6, 8, 9, 11, **68**, 69*, 101, 153
 headonensis, 26, **70**; Pl. IV, figs. 1-3
 spinosus, 66, 67, **71**, 78; Pl. IV, figs. 4-8
Lindera, 109
Linostoma, 149
Liriodendron, 9, 23, 24
 Ludian, 4
Lycopus, 151
Lygodium, 5, 37, 38
 sp. **37**

Magnolia, 23, 24
 Malpighiaceae, 95, 150
 Manosque, 35
 Marantaceae, 85
Marattia, 38
 MARTY, P., 16, 106
Meliosma, 24
Melissa, 6, 12, 29, 126
 officinalis, 126
 parva, 11, **126**; Pl. VIII, figs. 15, 16
 Messel, nr. Darmstadt, 51
Micrechites, 124, 125
Mitozus, 121
 Monocotyledones, 60
Monocotylrophyllum, 87
 sp. **87**; Pl. V, fig. 12
 Monte Promina, 25, 26, 28, 35
 Museum of Practical Geology, 2, 79
Myrica, 5, 6, 12, 152, 153
 asplenifolia, 153
 dryandraefolia, 153

 Najadaceae, 72
Najas, 12, 68, 72
 gracillima, 73
 graminea, 72
 Kingii, 72
 major, 68
 marina, 72
 oligocencia, 11, **72**; Pl. IV, fig. 10
Neolitsea, 12, 109
 cinnamomea, 110
 sp., 11, **109***; Pl. VII, figs. 13-16
 umbrosa, 110
Neuropeltis, 149
 Nigeria, 36

- NIKITIN, P. A., 112
Nuphar, 114
 ovatum, 113
 Nymphaeaceae, 12, 99
Nymphaea doris, 100

 Oeningen, 104, 124
Omphalodes platycarpa, 29
Ononis vetusta, 134
Oreodaphne, 109, 110
 foetens, 109
Oreomunnea, 24, 90
 Osborne Beds, 167-8
Osmanthus, 156
Osmunda, 38
Ottelia, 12, 73
 alismoides, 74
 britannica, 11, **73**; Pl. IV, figs. 11, 12
 parisiensis, 74
Oxylobium, 156

Pagiophyllum, 50
Palaeothrinax, 2, 3, 80
 Mantelli, 5, 11, 26, **80**; Pl. V, figs. 1-5
Palmacites Lamanonis, 80, 81
 Palmae, 79
Palmophyllum, 65, 80
 sp., **80**; Pl. IV, fig. 27
 Pandanaceae, 30
Papaver, 6, 12, 101, 111
 pictum, 8, 11, 29, **111**; Pl. VII, figs. 18, 19
 rupifragum, 29, 111
 Papaveraceae, 111
 Paris Basin, 4, 100
 Parschlug, 91
Parthenocissus, 27
Passiflora Braunii, 84
Pentamera, 122
Pergularia, 125
Periploca, 122, 125
Phragmites, 153
Phyllanthera, 29, 122, 125
 perakensis, 123; Pl. VIII, fig. 12
 vectensis, 11, **122**; Pl. VIII, figs. 8-11
Phyllites, 27, 161
 sp., **161**, 162*; Pl. XI, figs. 10, 11
Phyllocladus, 163
Picea, 23, 56
 excelsa, 56
 schrenkiana, 56
 pine-needles, 6, 55
Pinites Dixoni, 53
Pinus, 11, 12, 53
 Dixonii, 5, **53**, 54
 halepensis, 54

Pinus—
 laricio, 54
 mugho, 54
 pyrenaica, 54
 vectensis, 5, **54**
 sp. 1, **54**; Pl. II, fig. 20
 sp. 2, **55**; Pl. II, figs. 21, 22
Pityospermum ambiguum, **55**; Pl. II, fig. 23
Platycarya, 24, 30, 94
 Podostemaceae, 152
 Polygonaceae, 142
Polygonum dumetorum, 142
 Polypodiaceae, 33
 Pont-de-Gail, 14, 16, 17, 20, 25-29, 63, 83, 96
Potamogeton, 6, 8, 9, 12, 44, 66, 69*, 101, 104
 acutifolius, 69
 cristatus, 69
 pygmaeus, 11, 26, **66**, 78; Pl. III, figs. 19-22
 trichoides, 69
 sp. (*pygmaeus*?), **67**; Pl. III, figs. 23, 24
 sp. 2, **68**; Pl. IV, fig. 9
 Potamogetonaceae, 66
Pottsia, 121, 125
 preservation, 5
Prestonia, 121
 Proteaceae, 156
 Prunoideae, 144
Prunus, 24
 Pteridophyta, 33
Pteris, 35
Pterocarya, 9, 24, 30, 95
 caucasica, 24
 Forrestii, 30, 95
 hupehensis, 95
 stenoptera, 30, 95

Quercus, 97
 sp., 11, **97**; Pl. VI, fig. 12

Radermachera, 6, 129, 130, 155
 glandulosa, 130; Pl. VIII, fig. 21
 pulchra, **129**, 155; Pl. VIII, fig. 20
 sinica, 130
Radoboj, 91
 Ranunculaceae, 101
Ranunculus, 3, 6, 7, 9, 12, 103
 crassipes, 104
 emendatus, 104
 heterostylus, **103**; Pl. VII, figs. 1-4
 Purshii, 104
 rivularis, 104
 thasius, 104
 Wilkommianus, 104

- RENAULT, M. B., 24
 Reuver, 12, 25, 28, 83
 Reuverian, 9
Rhabdadenia, 120
 Rhamnaceae, 115
Rhamnospermum bilobatum, 11, 26, 117; Pl. VIII, figs. 1, 2
Rhamnus catharticus, 118
dahuricus, 118
Rheum, 142
 rhizomes, 163; Pl. XI, figs. 15, 16
 Rhizosperma, 30, 42
Rhododendron, 24, 25
Rhus, 5, 154, 155
macilentia, 154
 roots, 163; Pl. XI, figs. 12-15
 Rosaceae, 144
 Rubiales, 141
Rubus, 24
Rumex maritima, 9
Ruppia, 68, 69*, 70
 Rutaceae, 114
- Sabal major*, 3, 5, 11, 26, 79; Pl. IV, fig. 26
 Sagor, 91, 95
 St. Jean de Garguier, 25, 26, 28
 St. Zacharie, 25, 26, 28, 91, 92
Salix, 24
 Saltmead Ledge, 1, 166
 Salviniaceae, 40
Samaravectis, 12, 142
ovalis, 11, 142; Pl. IX, figs. 14-16
 Samland, 25
 Sannoisian, 4, 28
 SAPORTA, G. de, *passim*
 SARGENT, C. S., 22, 24
Sargentodoxa, 23
Sassafras, 23
 scars, 164; Pl. XI, figs. 17-20
Schima, 23
 Schizaeaceae, 37
 Schosnitz, 25, 28
Scolopendrium, 38
 Sconce Point, 166
 SCOURFIELD, D. J., 170
 Sedgwick Museum, 2, 35, 48, 150, 151
 Selaginellaceae, 152
 sepal or bract, 161; Pl. XI, fig. 9
Sequoia, 51, 56, 57
Coultsiae, 5, 26, 56
Sternbergii, 51
 SEWARD, A. C., 36, 50
 shrinkage, 7
Sinofranchetia, 23
Sinowilsonia, 23
- SMITH, J. E. E. A'COURT, 1-4, 33, 99, 127, 166
 Sotzka, 25, 26, 28, 51, 91, 95
 Sparganiaceae, 63
Sparganium, 6, 9, 12, 29, 30, 44, 63, 85
eurycarpum, 29, 64
Greeneri, 29, 64
multiloculare, 11, 29, 63, 80; Pl. III, figs. 12-18
 ovale, 29, 63
ramosum, 29, 30, 63, 64
valdense, 64
Spirematospermum, 6, 84
Wetzleri, 11, 26, 84, 86; Pl. V, figs. 6, 7
 STAMP, L. D., 4
 Stampian, 4, 28
 stems, 163
Sterculia, 157
labrusca, 157
Stratiotes, 6, 12, 16, 29, 36, 74
acuticostatus, 75
neglectus, 5, 11, 74, 113; Pl. IV, figs. 13, 14
Strobilidia, 86
Strophanthus, 120, 125
 Studland, Dorset, 35
Styrax, 24
Symplocos, 24
- Taxodineae, 56
 Tegelen, 12, 14, 16, 17-19, 25, 27, 28
Terminalia Fenzliana, 93-95
 Ternstroemiaceae, 143
Tetraclinis, 59, 60
articulata, 60
Teucrium, 127
 Thorley, 166
 Thorness Bay, 1-3, 75, 101
Thrinax, 81, 82
Thuya, 59
Thuyopsis, 59
 Thymeliaceae, 149
Tolypella, 173
perpusilla, 173
Trichopus, 74
Trichospermae, 128
Tylophora, 123-125
antiqua, 11, 123, 124; Pl. VIII, fig. 13
exilis, 124
hirsuta, 124; Pl. VIII, fig. 14
Typha, 3, 6, 9, 12, 57, 58, 60, 95, 153
angustifolia, 61
elephantina, 61
javanica, 61
latifolia, 61
latissima, 11, 26, 44, 60; Pl. III, figs. 4-11

Typhaceae, 60

Ulmaceae, 142

Ulmus, 142

UNGER, F., *passim*

Urechites, 120

Urticaceae, 94, 97, 142

Valerianaceae, 146

Vallisneria, 12

Viburnum, 5, 158, 159

longistaminum, 159

tinus, 159

Vincetoxicum, 124

Vitis, 27

WARD, F. K., 23

WHITE, H. J. O., 4

Whitecliff Bay, 81, 166

Wilcox Beds, 92

WILSON, E. H., 22

Wrightia, 119

Yunnan, 23

Zanthoxylon, 12, 114

costatum, 11, 114; Pl. VII, figs.
20, 21

dissitum, 115

Zingiberaceae, 6, 12, 84, 86; Pl. V,
figs. 10, 11

Zingiberites borealis, 86

Zizyphus, 12, 115

glabrata, 117

paradisiacus var. *paradoxus*, 5,
11, 26, 115, 116*; Pl. VII, figs.

22, 23

trinervia, 117

Ungeri, 5, 116, 117

12 NOV 1926





1



2



4



10



3



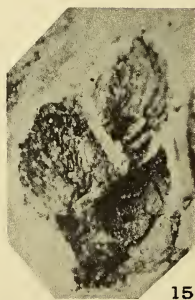
9



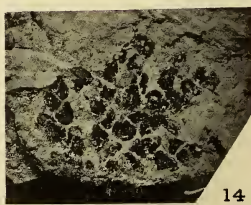
16



17

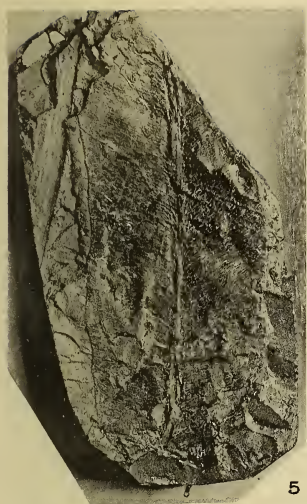


15

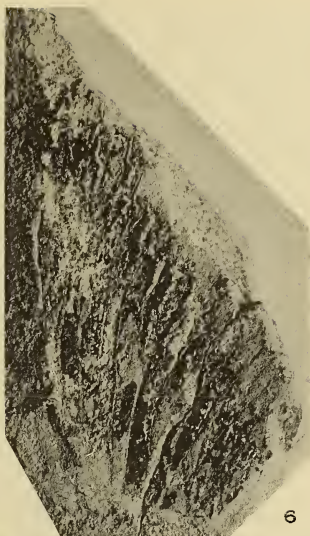


14





5



6



7



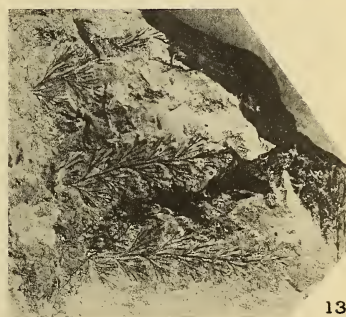
8



11



12



13



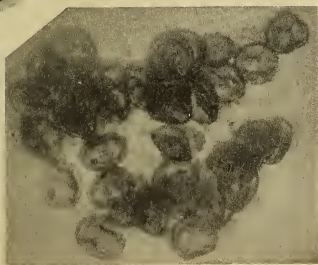
19



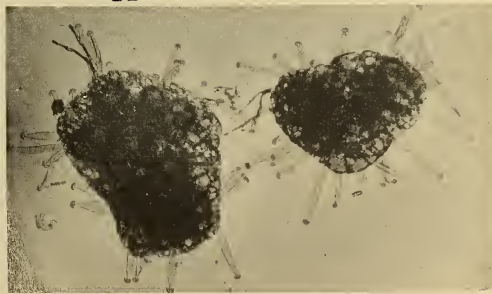
20



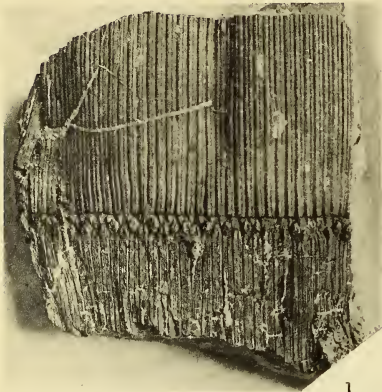
18



23



22



1



2



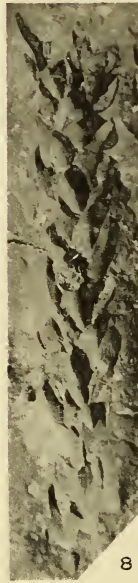
3



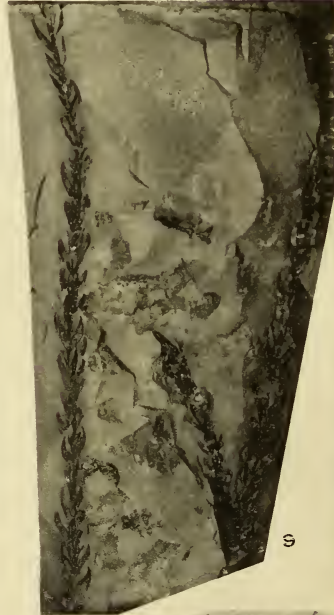
6



7



8



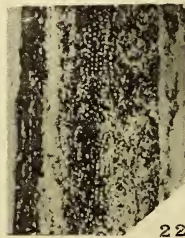
9



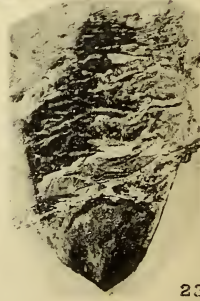
20



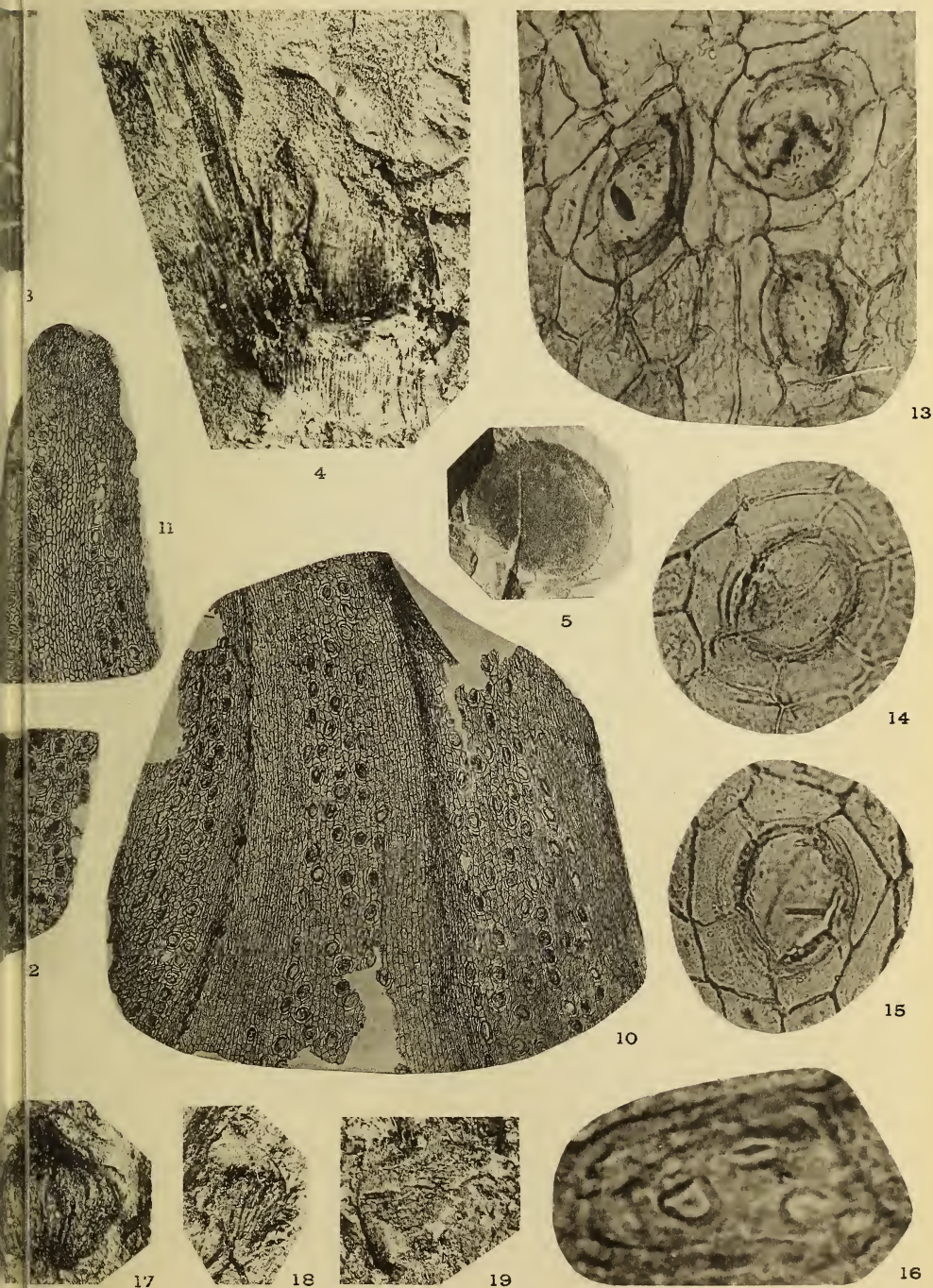
21



22

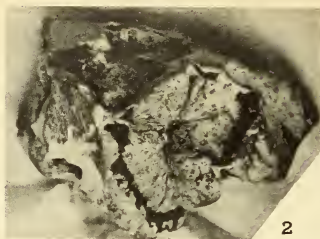


23





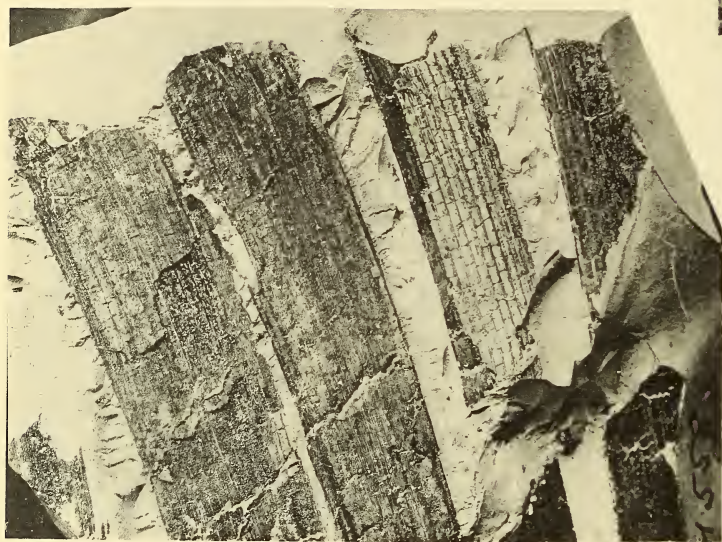
1



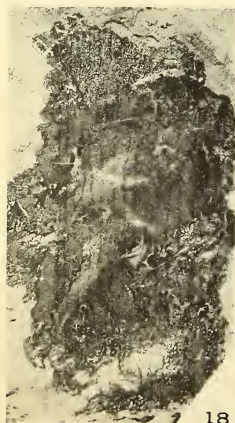
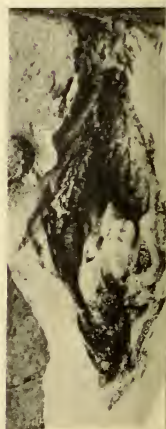
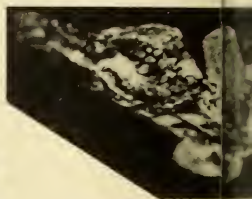
2



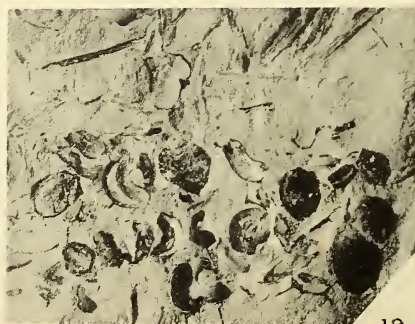
3



4



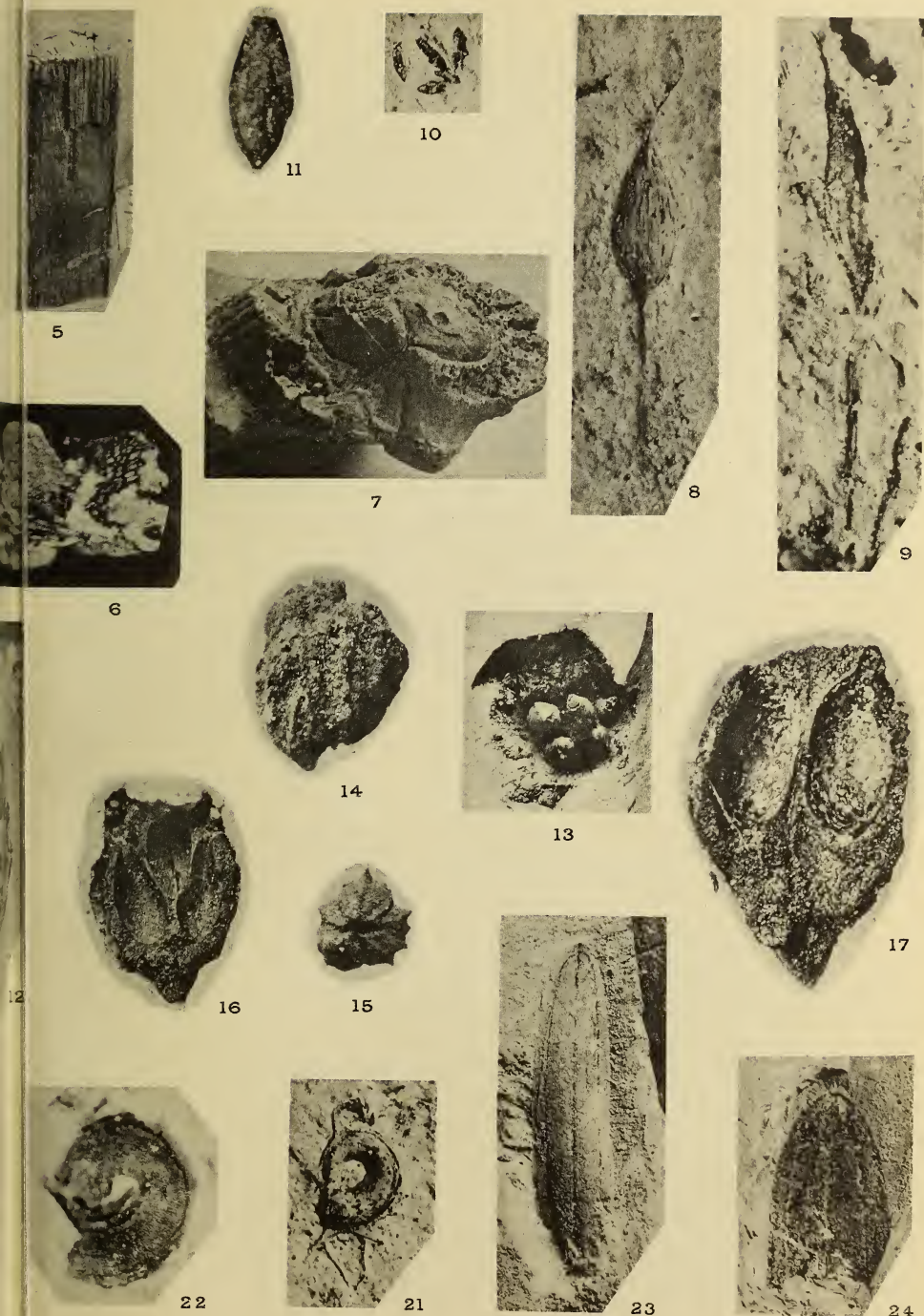
18

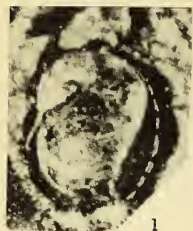


19



20

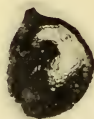




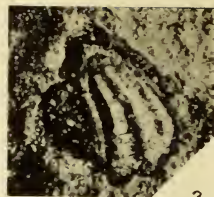
1



2



4



3



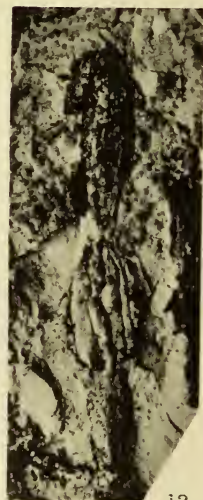
14



10



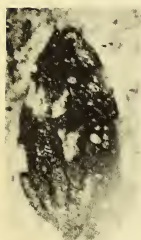
11



12



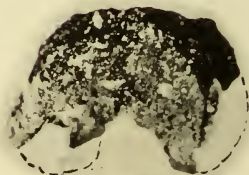
25



19



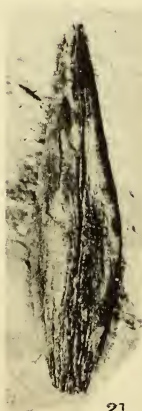
20



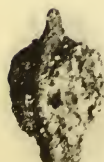
24



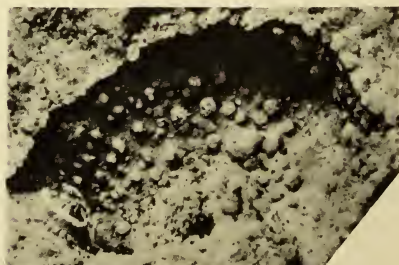
22



21



23





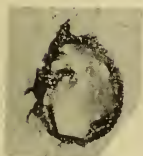
5



7



8



6



9



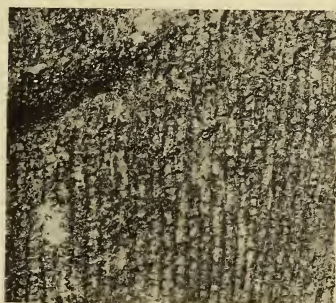
13



17



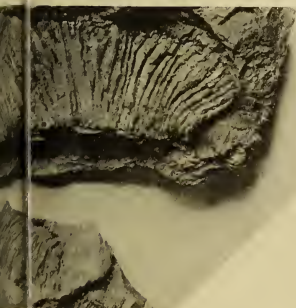
15



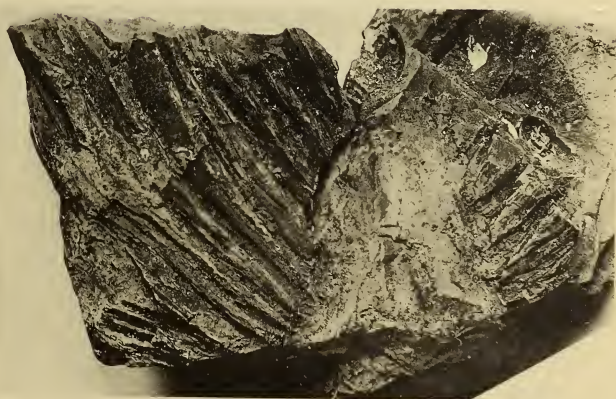
16



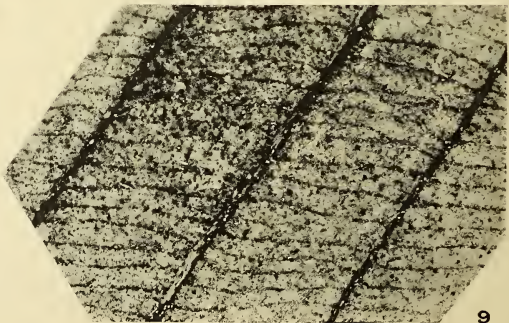
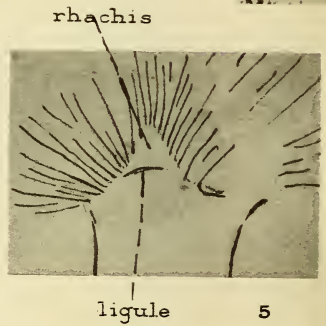
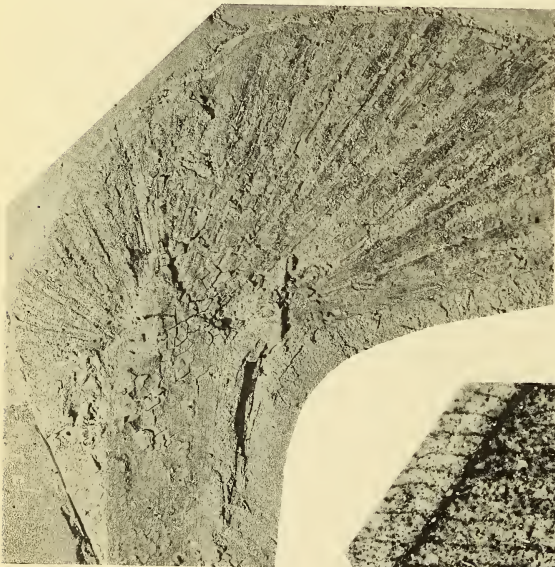
18



27

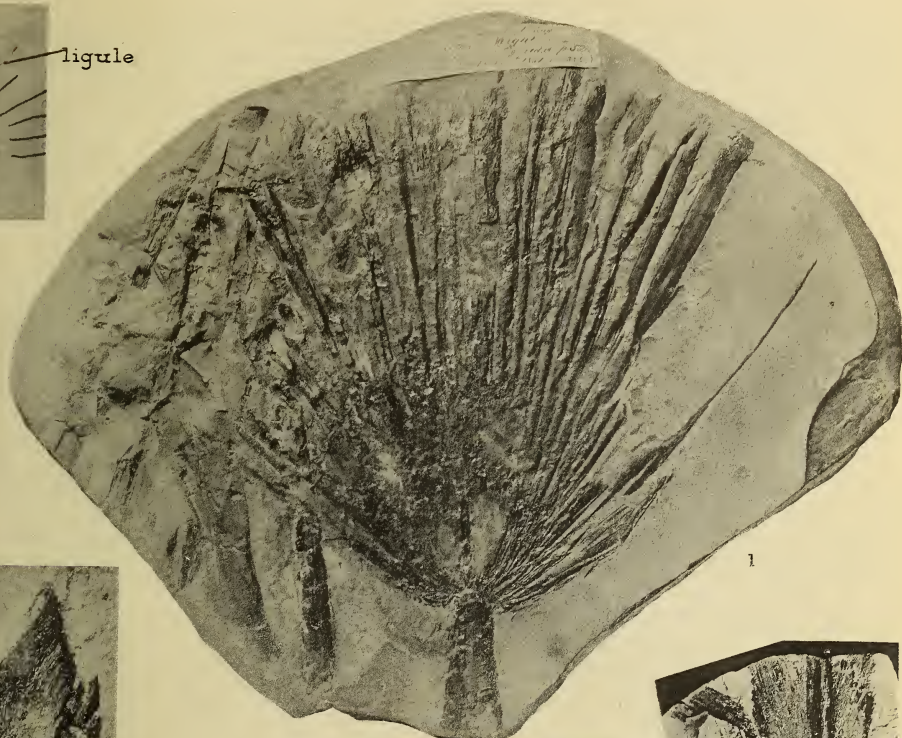


26





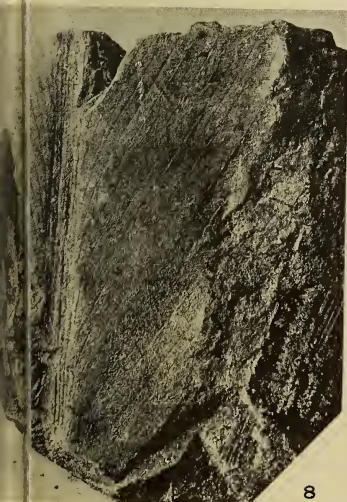
3



1



7



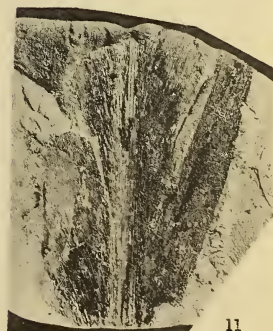
8



12



10



11



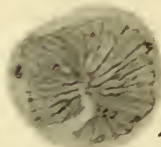
1



2



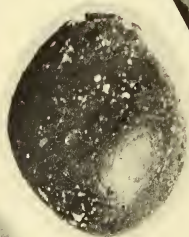
3



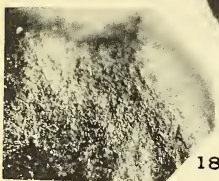
4



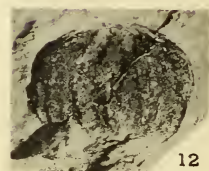
17



16



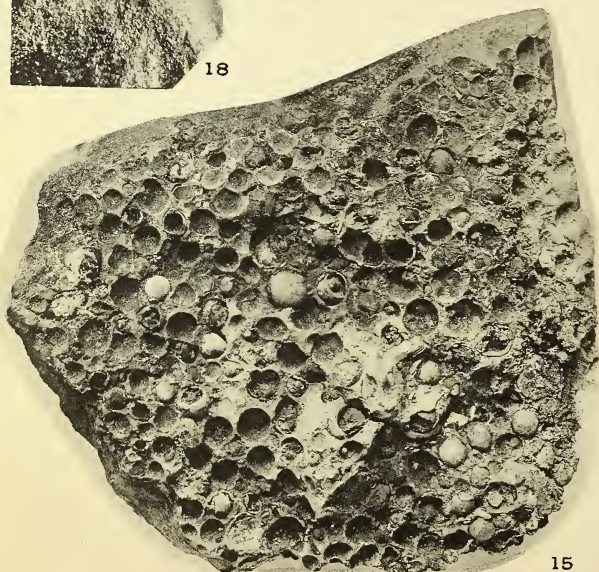
18



12



10



15



26

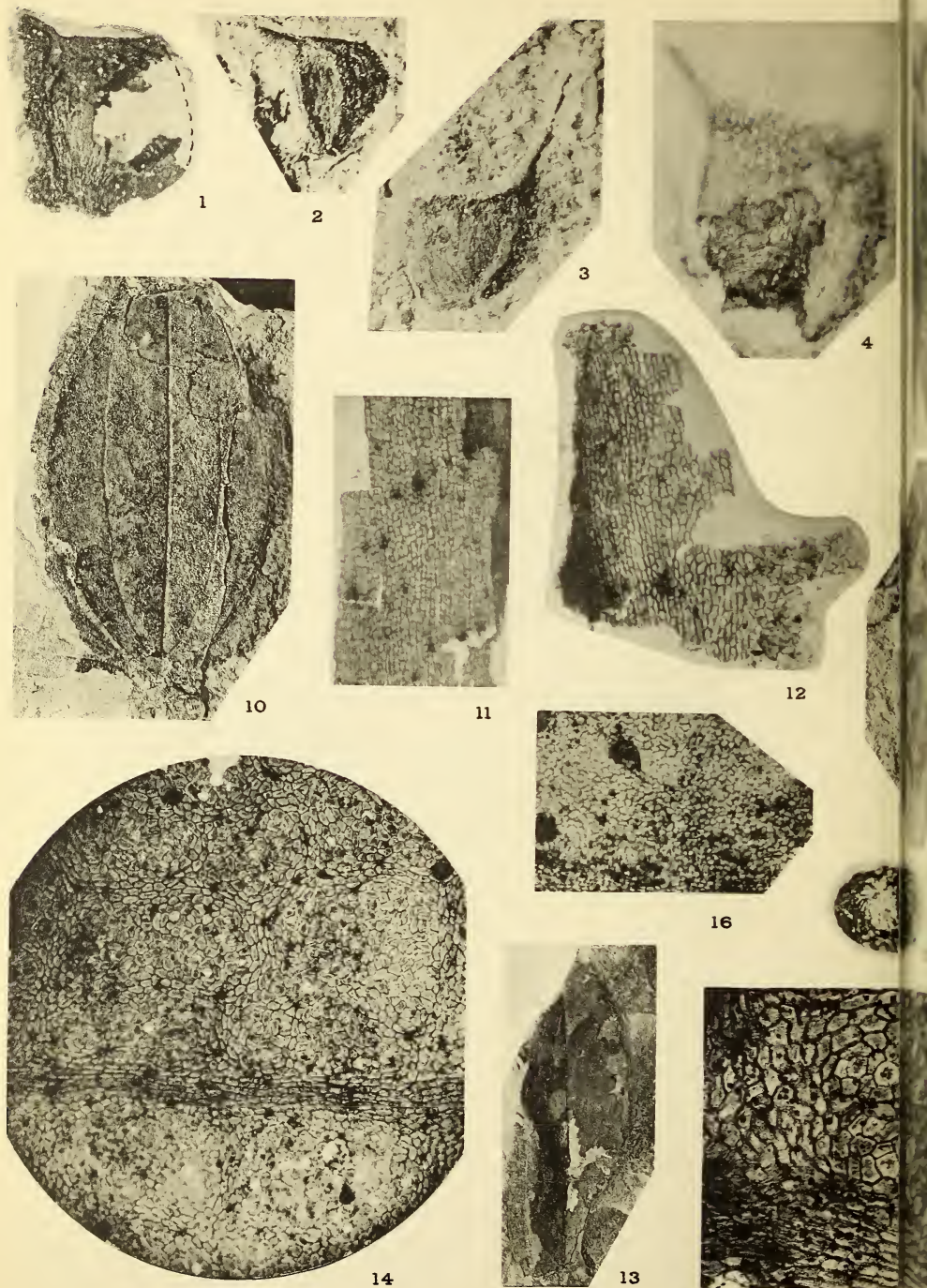


25

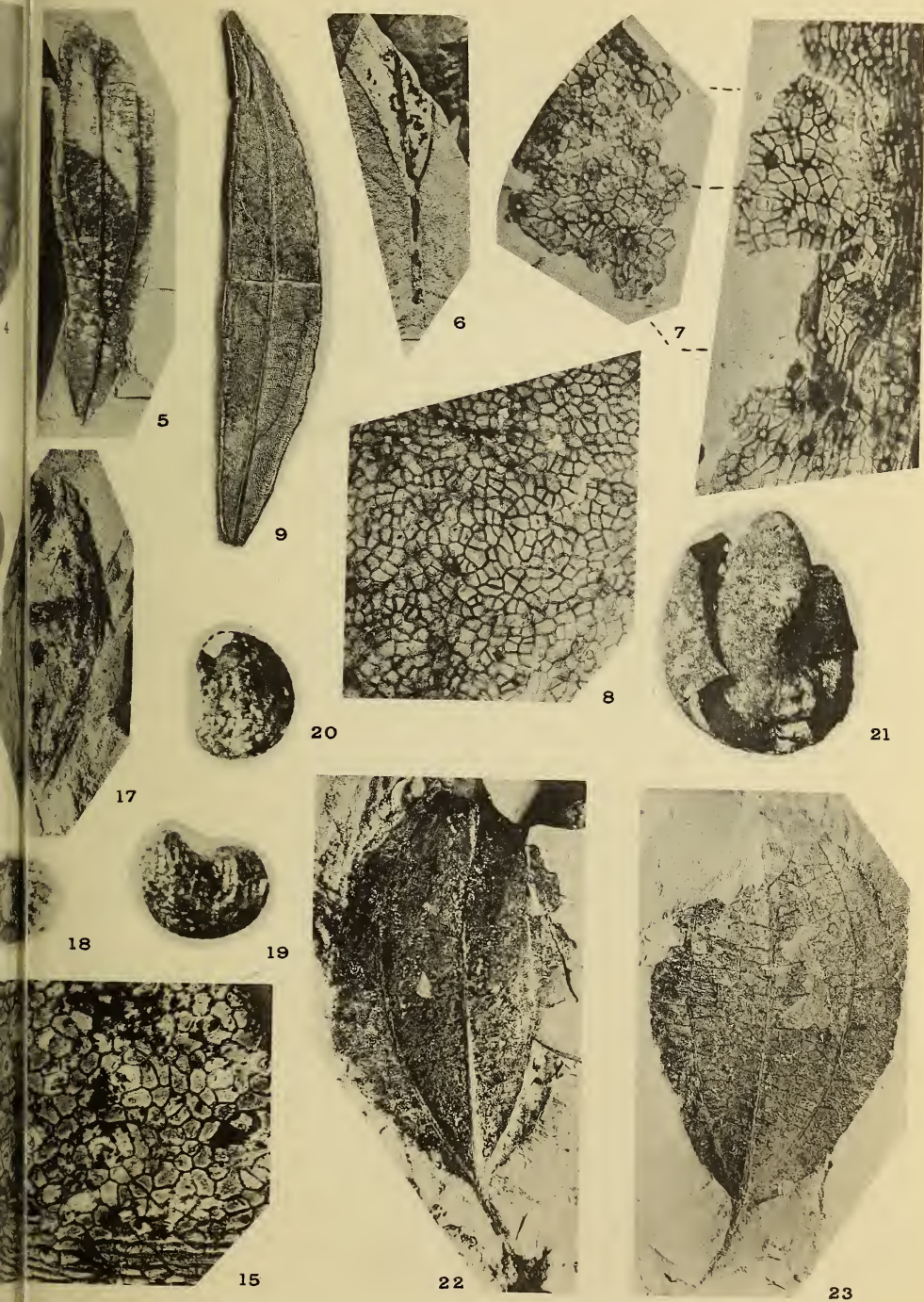


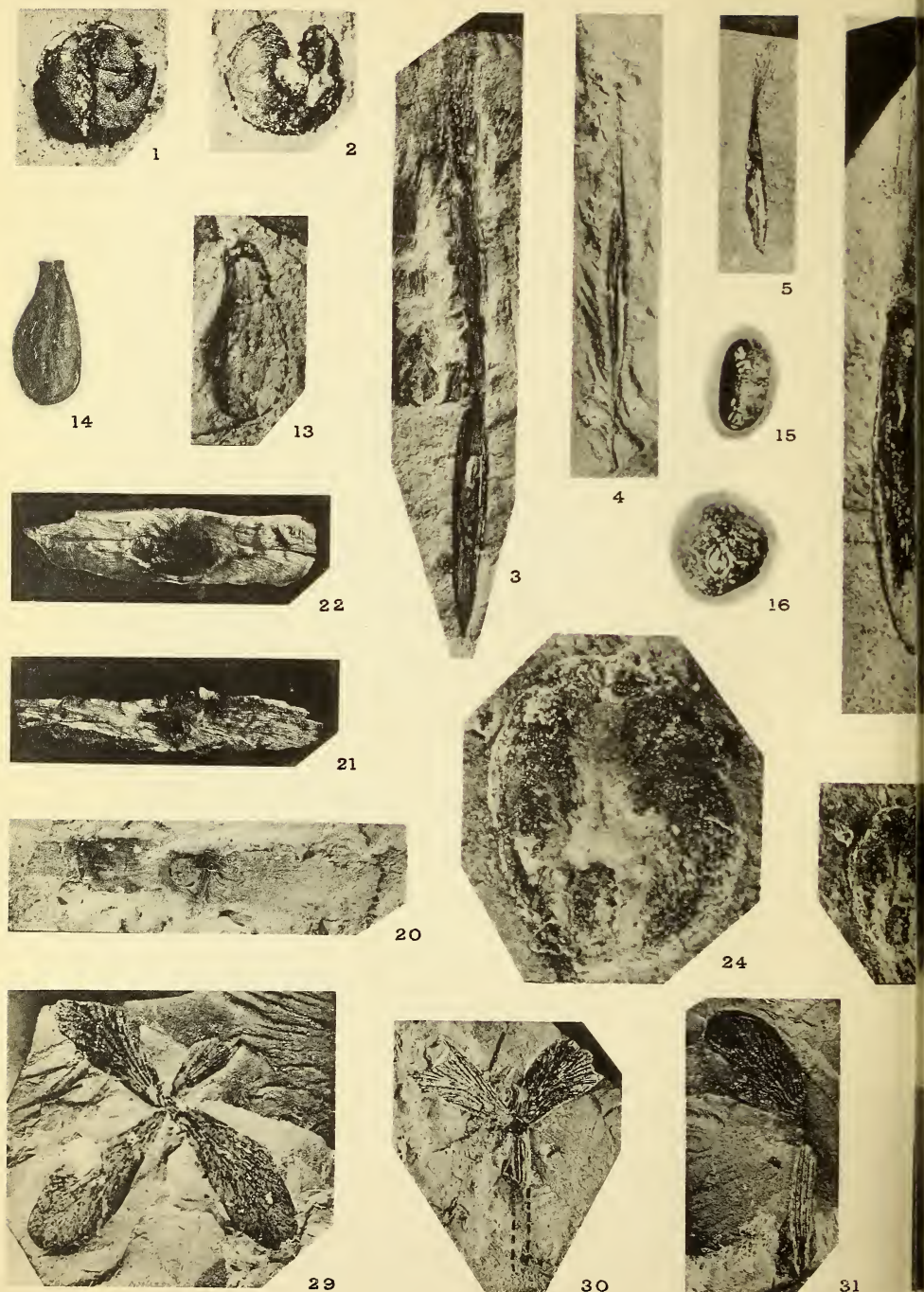
24

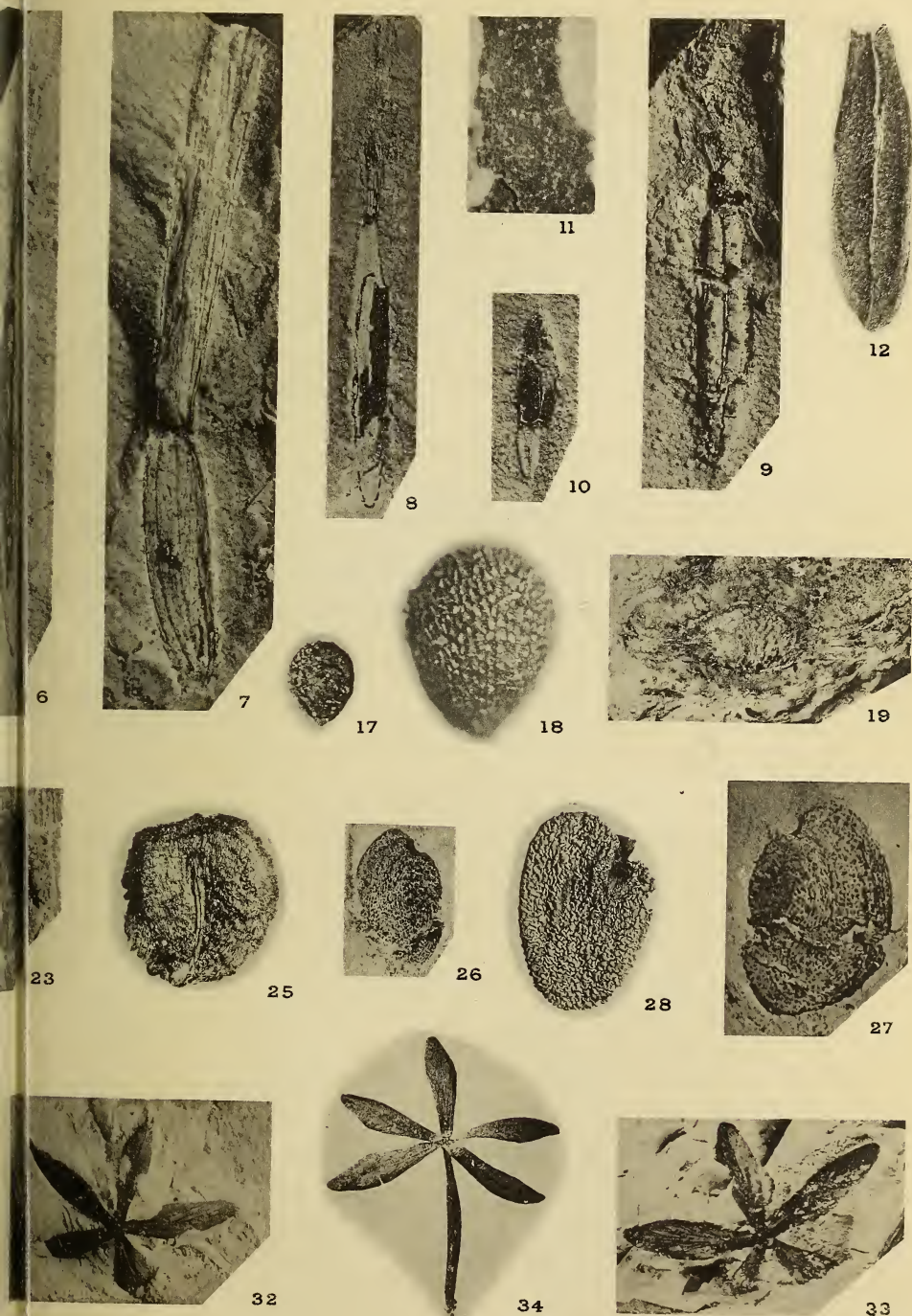




E.M.R. and M.E.J.C. photo









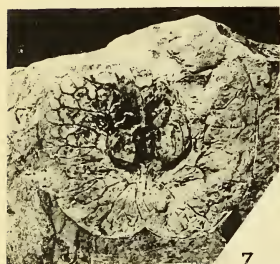
1



4



5



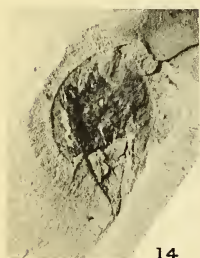
7



8



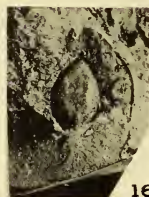
10



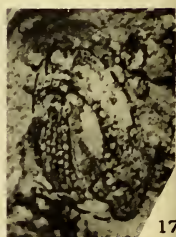
14



15



16



17



24

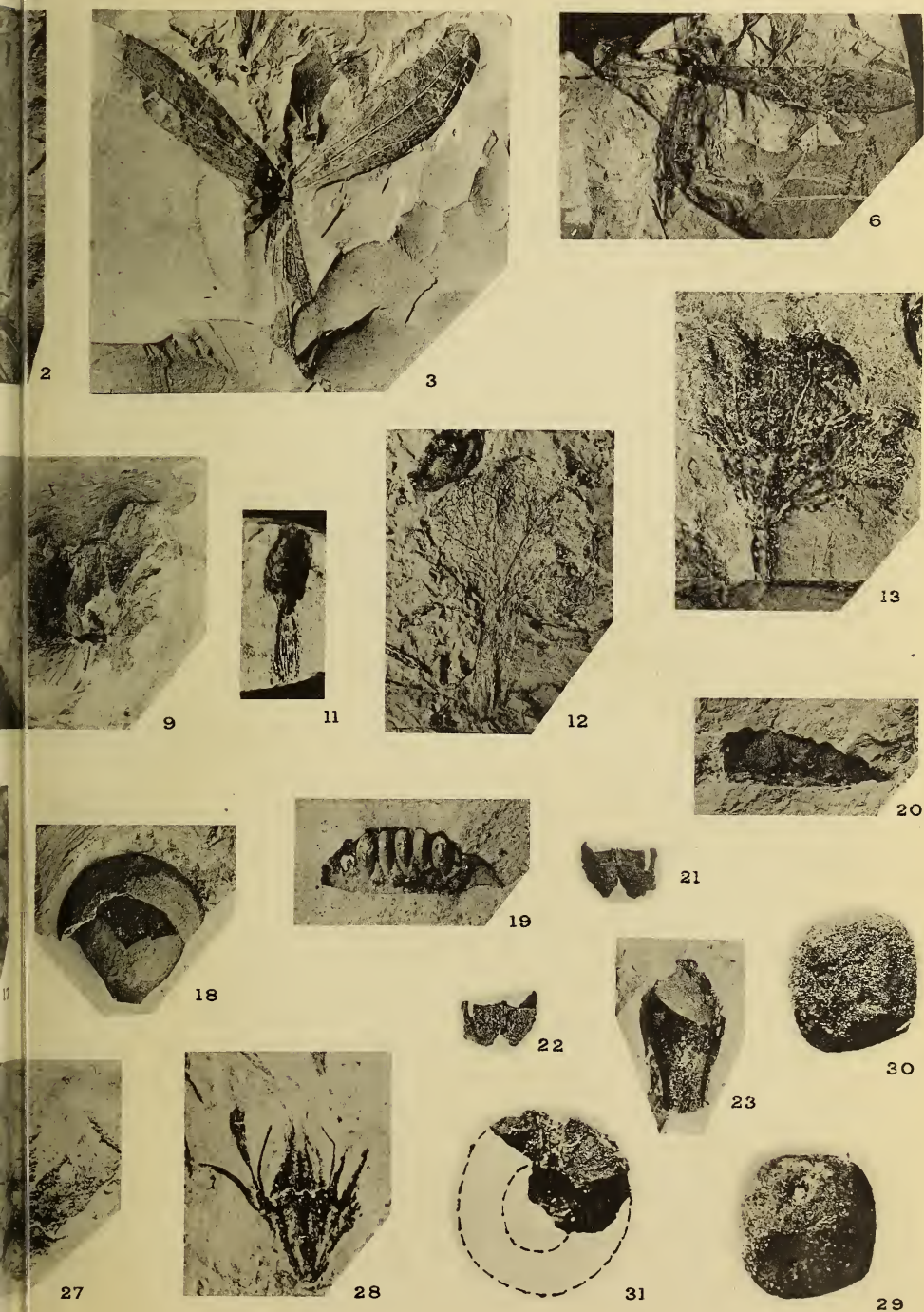


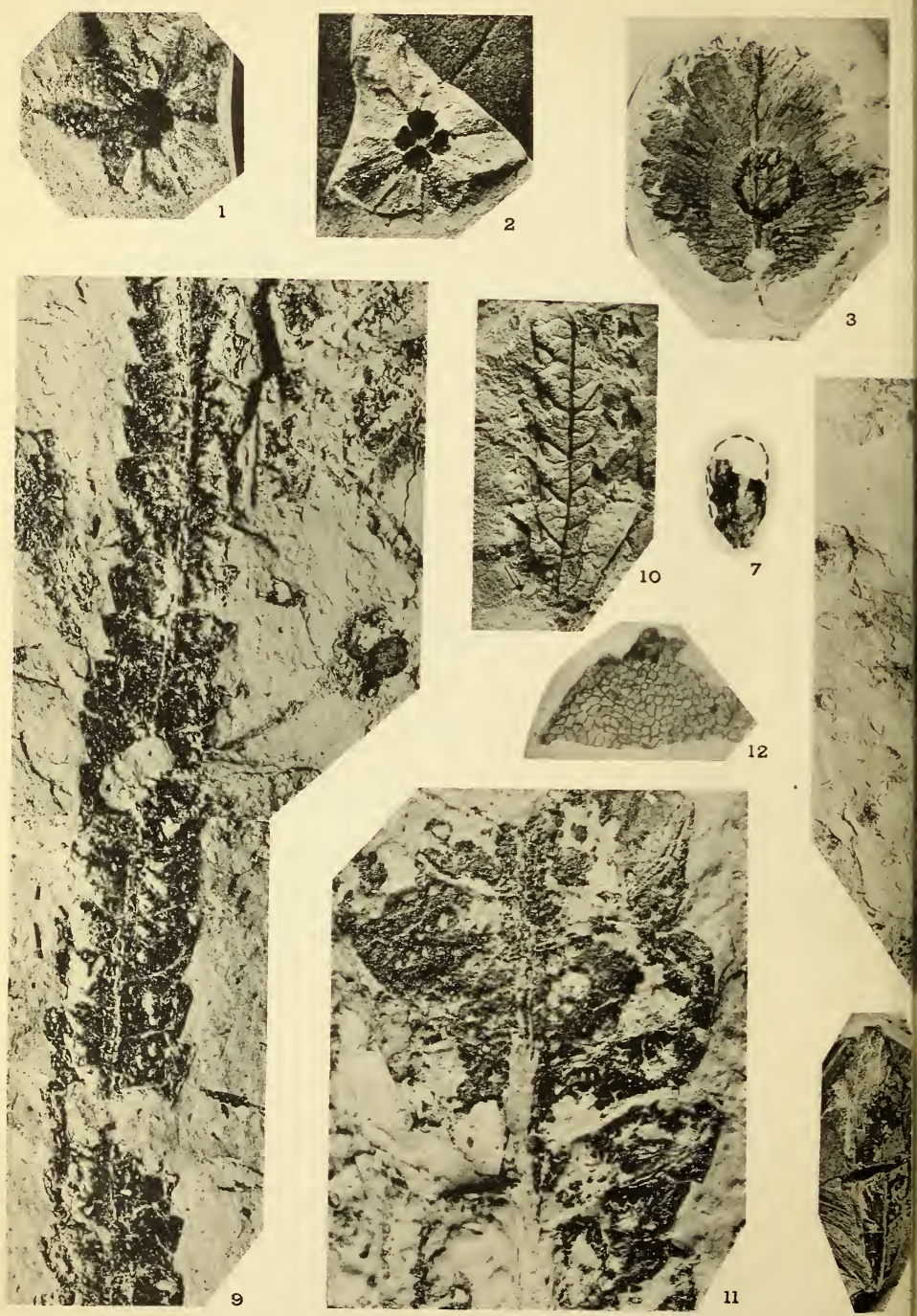
26



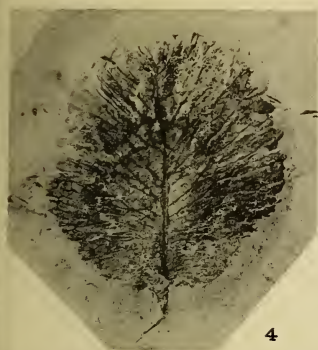
25



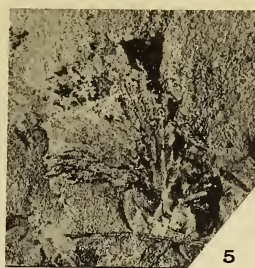




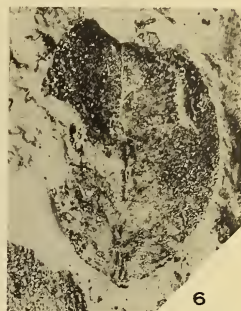
E.M.R. and M.E.J.C. photo



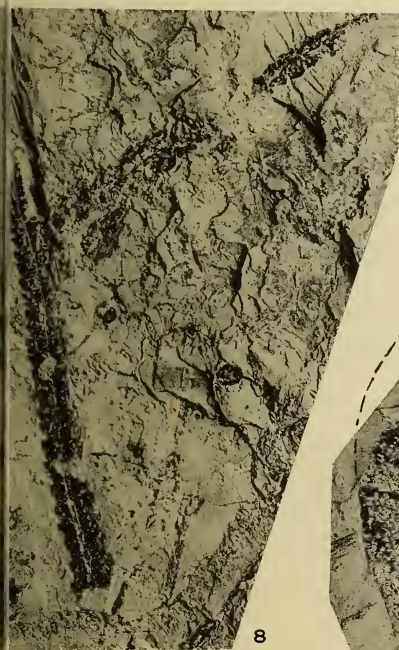
4



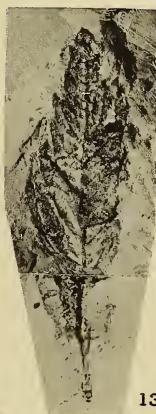
5



6



8



13



14



15



16



18



19



20



1



2



3



4



9



12



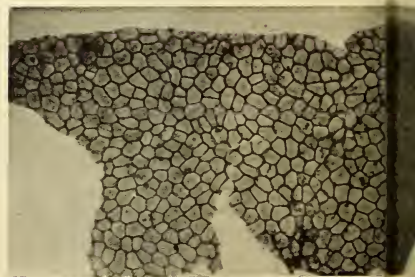
13

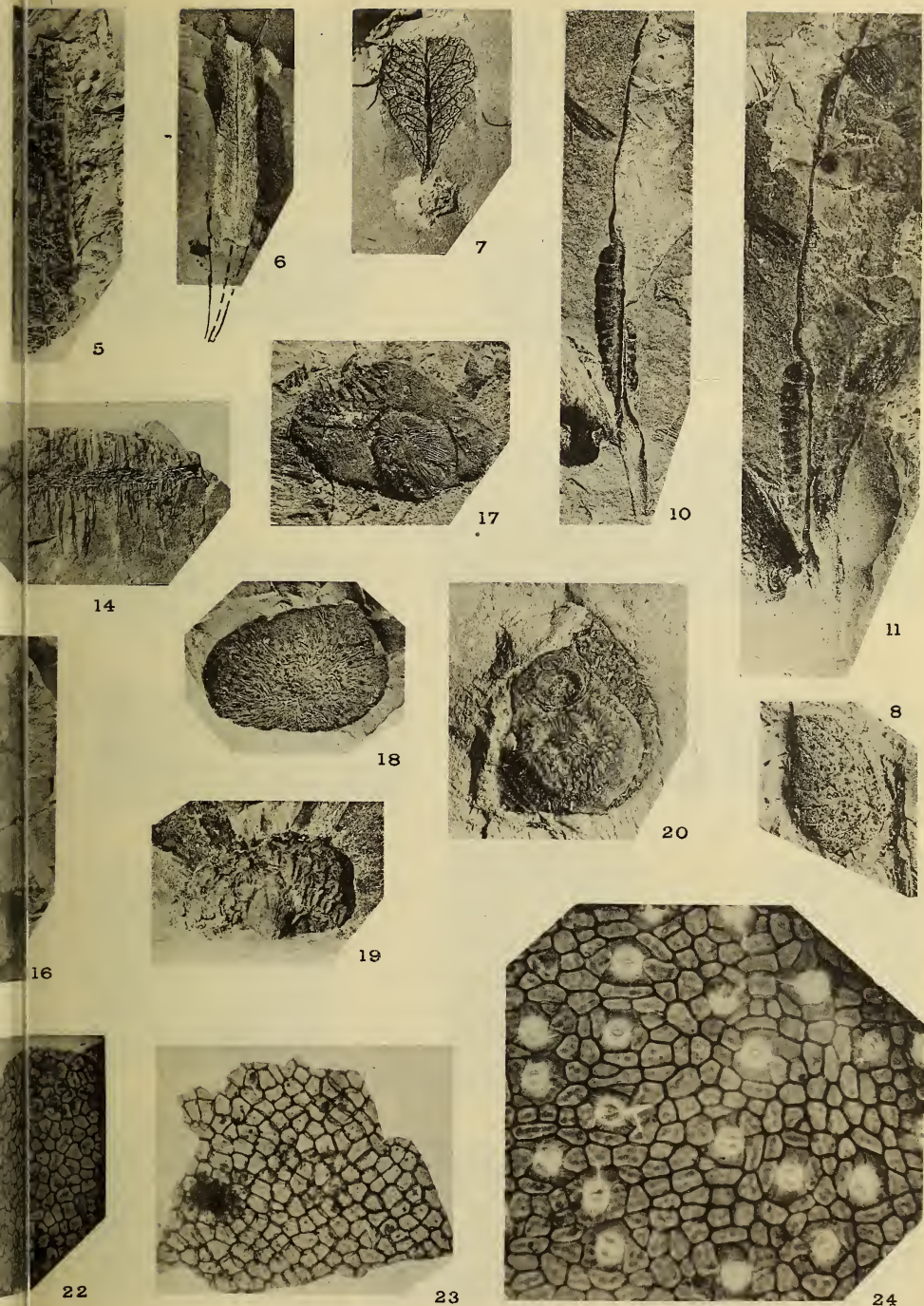


15

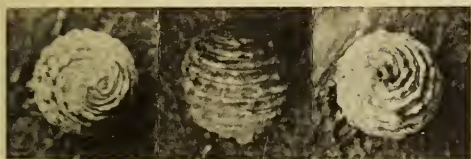


21





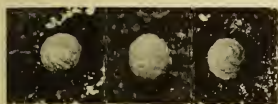




1



2



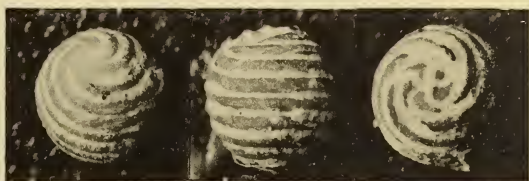
3



4



5



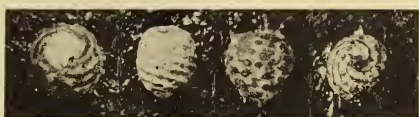
6



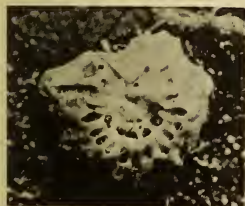
7



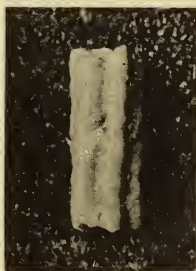
8



9



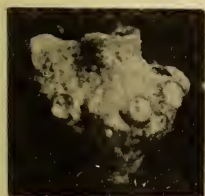
10



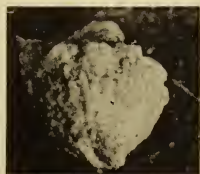
11



12



13



14



15



16

